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THE IMPACT OF THE NBC CLOTHING ENSEMBLE ON RESPIRATORY FUNCTION AND CAPACITIES DURING REST AND EXERCISE

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13. ABSTRACT (Maximum 200 words)

This study examined the effects of wearing a modified MOPP (mMOPP) overgarment (Protective Clothing, PC), configured with body armor (BA), Load Bearing Equipment (LBE), and M40 CB mask on the pattern and mechanics of breathing and cognitive functioning in 15 male soldiers at rest and during sustained submaximal exercise (~600 W). The M40 CB mask reduced breathing capacity 20%, and the PC+BA+LBE components of the mMOPP reduced it 5%. Total respiratory system compliance decreased by 16% in the mMOPP. Thus, wearing the PC+BA+LBE increased the "stiffness" of the soldier's respiratory system. During exercise, the mMOPP decreased tidal volume and increased respiratory rate, a compensation for the decreased respiratory system compliance. Although the M40 CB mask imposes a significant impairment to breathing, the PC with BA and LBE presents a unique external constraint on breathing, which may be more aversive than that imposed by the CB mask. These impairments may be reduced by wearing BA and LBE that are properly fitted over the PC and incorporating, in future designs, enhancements that allow for outward expansion of the PC, BA or LBE with inhalation.

14. SUBJECT TERMS

Chemical Protection, CB Mask, Protective Clothing, MOPP, Load Bearing Equipment, Body Armor, Respiratory Mechanics, Sensations, Mental Performance, Exercise, Pattern of Breathing

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BACKGROUND

On the battlefield, the soldier must be prepared to engage in operations in an NBC theater. However, the wearing of NBC protective clothing causes degradations in military operations (Taylor and Orlansky, 1991; Banderet et al., 1992). Recent studies have shown that various load carriage systems and body armor impair ventilation. However, the possible interactive effects of chest wall restriction (NBC overgarment+Body Armor+Load Bearing Equipment) and added inspiratory resistance (CB mask) on physical work and cognitive performance is not known. Many military tasks employed in infantry combat operations require moderate physical activity. Assessment of ventilatory function (physiological and psychological indices) under these conditions is useful in predicting ventilatory limitations to soldier work and cognitive performance and guiding strategies to reduce the adverse impact of clothing and equipment on respiratory function. This study was funded by TRADOC through the P^2NBC^2 program.

EXECUTIVE SUMMARY

The purpose of this study was to examine the effects of wearing the MOPP overgarment (Protective Clothing, PC), configured with a fighting load, body armor (BA), Load Bearing Equipment (LBE), and M40 Chemical-Biological Field Mask (M40 CB mask)--a combination that we call the modified MOPP uniform (mMOPP)--on the pattern and mechanics of breathing and cognitive functioning in 15 male soldiers at rest and during sustained submaximal exercise (~600 W). Results from wearing the mMOPP were contrasted with data from wearing the physical training uniform (PTU), or modified Battle Dress Uniform (mBDU). Heat strain on each soldier was minimized and equalized between the mBDU and mMOPP uniform configurations by testing in cool, dry, environments and shortening the sleeves and trousers of both uniforms to facilitate heat transfer. These modifications to the uniforms allowed for the assessment of MOPP induced ventilatory limitations to exercise independent of heat strain.

The measurement of pulmonary function and chest wall displacement provided a quantitative determination of the respiratory load imposed by wearing each uniform. The mMOPP decreased maximal breathing capacity by ~25% compared with the PTU (baseline). The M40 CB mask reduced breathing capacity 20%, and the PC+BA+LBE components of the mMOPP reduced it 5%. The M40 CB mask significantly decreased respiratory flow, where as the PC+BA+LBE components significantly decreased lung volumes, but had no effects on airflow. The decreased lung volumes were likely the result of the constrictive nature of the PC+BA+LBE components on the chest wall. Accordingly, total respiratory system compliance was decreased by 16% in the mMOPP. Thus, wearing the PC+BA+LBE components increased the "stiffness" of the soldier's respiratory system, decreasing maximal ventilatory capacity and increasing the work of breathing.

During submaximal exercise, minute ventilation was comparable for both the mMOPP and mBDU; however, when wearing the mMOPP, tidal volume was smaller and respiratory rate significantly greater. The smaller tidal volume during exercise in mMOPP

is a compensation for the decreased compliance of the respiratory system caused by the wearing of the MOPP overgarments, BA and LBE. Although these uniform components caused a smaller impairment in breathing capacity than the M40 CB mask, the subjects adjusted their pattern of breathing to compensate for the smaller elastic load rather than the larger resistive load. Moreover, perception of anxiety, not getting enough air, not breathing the way one usually does, and not being relaxed were greater in the mMOPP than in the mBDU. The fact that such effects were not related to the duration of exercise per se suggests that the uniform type itself creates changes in symptoms and perceived internal states that greatly influence the soldier's appraisal of discomfort and averseness in this situation. Although the M40 CB mask imposes a significant impairment to breathing, this study shows that the MOPP overgarment with fighting load presents a unique external constraint on the chest wall, which maybe more aversive than the larger resistive loads imposed by the M40 CB mask.

We hypothesized that performance of a cognitive task involving speech during exercise would also compromise ventilation. Minute ventilation was decreased ~11% during the first minute of the 3-minute speech task compared with steady-state exercise. Such changes during exercise were identical for both uniforms. These data suggest that tasks requiring sustained speech or vocal sounds may hinder the soldier's ability to maintain adequate ventilation during exercise or heavy physical work.

This study demonstrates that besides the M40 CB mask, MOPP overgarments, BA and LBE substantially restrict breathing. The last three items' constrictive liabilities to the chest wall can be reduced by wearing BA and LBE that are properly fitted over the protective clothing. Future designs of these uniforms and personal equipment for the soldier may incorporate enhancements that allow for outward expansion of the uniform or LBE with inhalation. Since our data suggest that the elastic forces opposing breathing produce greater adjustments of the breathing pattern than the resistive forces contributed by the M40 CB mask, incorporation of elastic loading in training programs to improve work performance and tolerance in MOPP may prove beneficial in reducing ventilatory casualties in MOPP.

INTRODUCTION

The wearing of nuclear-biological-chemical (NBC) protective clothing (PC) causes a degradation in the performance of military operations (Taylor and Orlansky, 1991; Banderet et al., 1992). The magnitude of performance decrements incurred is dependent upon a complex interaction between human, mission (e.g., uniform, equipment and task), and environmental factors. The effect of the chemical-biological protective (CB) mask on respiratory function has been of particular interest. Many studies have documented the effect of added inspiratory resistance on cardiopulmonary and exercise performance (Muza, 1986). These studies have shown that ventilation is not impaired by CB mask wear at low to moderate exercise intensities (<60% $\dot{V}O_2max$). Yet, many reports have attributed compromised physical work performance to mask-induced symptoms of respiratory distress (Muza, 1986; Munro et al., 1986; Taylor and Orlansky, 1991; Banderet et al., 1992; Tyner et al., 1989). Moreover, several instances of respiratory impairments, apparently related to CB mask wear, have been reported during the conduct of research protocols studying low to moderate intensity work in NBC clothing (Cadarette, 1992; Tyner et al., 1989).

The CB mask has usually been the focus of research relative to respiratory impairment associated with an NBC protective ensemble. Thus, excluded from study have been other components of the NBC ensemble such as the PC and/or LBE system that may interact and accentuate impairment of respiratory function. Previous studies performed by USARIEM personnel and others have shown that LBE systems worn over the Battle Dress Uniform (BDU) reduce maximum breathing capacity by ~10% (Muza et al., 1989; Quigley et al., 1993; Legg, 1988; Legg and Mahanty, 1985). We believe this reduction is the result of restricted motion of the chest wall caused by the overlying clothing and LBE. We hypothesized that the multiple layers of military clothing and load carriage equipment worn in the MOPP configuration imposes an additional external impedance on breathing mechanics beyond that caused by the CB mask. This hypothesis was tested by measuring the effects of wearing NBC equipment (PC and M40 CB mask), BA, and LBE on the mechanics and perception of breathing during rest and exercise.

Another challenge to the ventilatory system is phonation (i.e., speech and singing). Phonation causes two major modifications to the breathing pattern: a greater amount of the vital capacity is used and expiration is prolonged (Proctor, 1986). At rest, these disruptions of the breathing pattern do not cause hypoventilation. During MOPP studies conducted by Institute personnel (Cadarette, 1992), personnel noted increased respiratory complaints immediately following rapid speech (i.e., performance testing requiring verbal responses to Serial Sevens Task). Due to adequate ventilatory reserve capacity, speech may not be a constraint on moderate intensity exercise performance, although this is not well studied (Proctor, 1986). Still, as exercise intensity, and thus ventilatory demand, increases, most individuals find that attempting to maintain conversation adversely impairs physical performance. Thus, a second hypothesis was tested: if ventilatory capacity is already reduced by imposition of external mechanical constraints (PC, M40 CB mask, BA and LBE), phonation-induced disruptions of the breathing pattern will cause a ventilatory limitation on moderate physical work performance. To our knowledge, no previous investigation has examined the effects of phonation concurrent with external respiratory loads on ventilation during exercise.

Given that resistive and elastic loads to breathing elicit opposite ventilatory compensatory responses, we hypothesized that the combined effects of the M40 CB mask (a resistive load), the PC+BA+LBE (an elastic load) and a speech task (breathing pattern distortion) would be a significant strain on ventilatory capacities and ventilatory function during exercise. The work intensity of such exercise is like that of various combat infantry tasks (i.e., approach march, machine gunner fire fight, riflemen on assault, etc. (Goldman, 1965). Concurrent with impairments to physiological function, we hypothesized that increasingly stressful conditions will produce greater adverse effects on psychological functions (more intense symptoms, less positive emotion and impaired performance). Furthermore, the combination of these challenges may aggravate the development of adverse respiratory sensations and thus the perceived exertion of the physical work task.

The purpose of this study was to examine the effect of the NBC overgarment (PC) and M40 CB mask in combination with BA and LBE on the pattern and mechanics of

breathing during rest and sustained aerobic exercise (~600 W). The specific objectives were to assess the effect of the NBC ensemble on 1) ventilatory capacities, 2) respiratory system elastance, 3) pattern of breathing during rest and sustained moderate intensity exercise, 4) verbal tasks and exercise ventilation, and, 5) cognitive performance and subjective reactions. Since the occurrence of heat strain is commonly a limiting factor to exercise performance in MOPP and may confound assessment of ventilatory limitations, heat strain was equalized between the two uniform combinations. This was accomplished by using a cool, dry, ambient environment and shortening the sleeves and trousers of both uniforms to facilitate heat dissipation. These modifications to the uniform allowed for the assessment of MOPP induced ventilatory limitations to exercise independent of heat strain.

METHODS

SUBJECTS

Fifteen male test volunteers were studied. Subjects were recruited from military personnel stationed at Natick Research Development and Engineering Center. Descriptions of salient subject characteristics (Mean $\pm$ S.D.) are given in Table 1 and Appendix 1.

TABLE 1: SUBJECT CHARACTERISTICS

Age (yr)	Height (cm)	Weight (kg)	Peak $\dot{V}O_2$ (ml/kg/min)	HCVR (l/min/Torr)
24±5	177±12	80±10	53±5	2.14±0.57

STUDY DESIGN

Four uniform combinations were tested: 1) Physical Training Uniform (PTU) consisting of shorts, T-shirt, and running shoes; 2) modified Battle Dress Uniform

(mBDU)+M40 CB mask with an empty C2 filter canister; 3) mBDU+M40 CB mask with a standard C2 filter canister, and 4) MOPP IV, modified (mMOPP) by removing the gloves, overboots, and hood. Furthermore, both the mBDU and mMOPP uniforms' jacket sleeves and pants were shortened to facilitate heat transfer during exercise. These uniform modifications retained the external loads on the torso presented by the standard MOPP uniform, while minimizing the heat strain inherent to the MOPP uniform. Additionally, over the mMOPP uniform, the volunteers wore BA (fragmentation protective vest) and LBE (pistol belt with suspenders) configured with a fighting load minus a weapon. This load consisted of 2 full canteens and 2 ammo carriers, each loaded with the equivalent of 4 full 5.56 mm 30 round magazines. The components and weights of each uniform are listed in Table 2.

TABLE 2: TEST UNIFORM COMPONENTS

UNIFORM ITEM	mBDU	mMOPP	WGT (kg)
BDU: shorten sleeves and trousers			1.3
Running shoes			1.0
Protective clothing: shorten sleeves and trousers			1.0
M40 CB mask with empty C2 filter canister			1.0
M40 CB mask with standard C2 filter canister			1.0
Body armor, fragmentation, protective vest, ground troop			4.4
LBE: pistol belt, suspenders, 2 loaded canteens and 2 loaded ammo pouches			5.9

These two uniform/equipment configurations (mBDU and mMOPP) were selected because 1) both are commonly used in the field, 2) the mMOPP configuration presents an external mechanical load on the chest wall and airway, and 3) the mMOPP configuration is similar to conditions during which respiratory impairments were reported

by previous studies. The specific tests performed in each uniform combination are given in Table 3.

TABLE 3: TEST PROCEDURES PERFORMED IN EACH UNIFORM COMBINATION

	PT Uniform	mBDU + CB Mask with empty C2 filter canister	mBDU + CB Mask with standard C2 filter canister	mMOPP (PC+BA+LBE)
Peak Oxygen Uptake Test				
HCVR Test				
PFTs				
Chest wall Mechanics				
Resting Ventilation				
Submaximal Exercise				

TEST PROCEDURES

All studies were performed within the laboratories of the U.S. Army Research Institute of Environmental Medicine (USARIEM). Test procedures fell into two general categories: resting studies or exercise studies. Test days alternated between resting and exercise studies (Table 4).

TABLE 4: STUDY SCHEDULE

TEST DAY 1	TEST DAY 2	TEST DAY 3	TEST DAY 4	TEST DAY 5	TEST DAY 6
•ORIENTATION •QUESTIONNAIRE •COGNITIVE TASKS TRAINING	•HCVR TEST •FAMILIARIZATION WITH PFTs, TREADMILL •COGNITIVE TASKS TRAINING •PEAK $\dot{V}O_2$ TEST	•RESPIRATORY CHALLENGE TEST •PFTs	•SUBMAXIMAL EXERCISE TEST	•RESPIRATORY CHALLENGE TEST •THORACO-ABDOMINAL ELASTANCE	•SUBMAXIMAL EXERCISE TEST

1. Military and Background Information

Prior to the study, all volunteers were evaluated with questionnaires (Beck, 1979; Derogatis, 1983; Spielberger et al., 1970) to assess their military experiences and psychological constructs that influence ventilation (Table 5). The individual instruments in the assessment battery are shown in Appendix 2. The Military & Personal History Survey was developed at USARIEM in 1985 and has been used in P^2NBC^2 studies in the laboratory and field to document such things as ages, weights, PT Scores, chemical defense experiences, marital status, and recent life experiences of soldiers (Munro et al., 1986; Blewett et al., 1992; Blewett et al., 1993). The SCL-90-R (Derogatis, 1983) measures symptoms, typical behaviors, and responses to stress so that characteristic levels of anger, hostility, and anxiety are known for each soldier. The BDI and BHS scales (Beck, 1979) measure depression and hopelessness, respectively. The Self Evaluation Questionnaire (Spielberger et al., 1970) measures the level of "background" anxiety that is typical for each soldier. Such psychological constructs influence an individual's tolerance of the mask and perception of ventilatory changes (Morgan, 1983). All questionnaires were administered as mark-sense media and coded with a two-digit subject identifier. To avoid possibility of the investigators or staff biasing the study's outcome, the questionnaires were not examined or analyzed until all data collection was completed.

TABLE 5: QUESTIONNAIRES ADMINISTERED BEFORE THE STUDY TO EVALUATE THE VOLUNTEERS' MILITARY EXPERIENCES, RESPONSES TO STRESS, AND PERSONALITY CHARACTERISTICS

ASSESSMENT INSTRUMENT	SUBJECT'S RESPONSE	TEST SCHEDULE	MINUTES REQUIRED
Military & Personal History Survey	Mark-sense	Before study	30
SCL-90-R	Mark-sense	Before study	20
BDI	Mark-sense	Before study	15
BHS	Mark-sense	Before study	10
Self Evaluation Questionnaire:X-2	Mark-sense	Before study	5

2. Pulmonary Function Tests

These measures were made to characterize the volunteer's pulmonary function and possible impairment resulting from wearing the mMOPP uniform. The three uniform configurations tested were chosen to delineate between the impact of the CB Mask and torso loads on pulmonary function. All tests were performed using a computer controlled, dry-rolling seal spirometry system (Sensormedics 2450 PFT System). Measured variables included spirometry (forced volumes and flows), maximal voluntary ventilation, lung volumes by helium dilution, diffusion capacity by the single breath carbon monoxide technique and total respiratory system impedance (i.e., pressure-volume relaxation characteristics). All spirometry measures, except lung diffusion capacity, were performed three to eight times until reproducibility criteria (Gardner et al., 1987) were achieved.

3. Progressive Hypercapnic Ventilatory Response (HCVR)

The purpose of this test was to assess each volunteer's ventilatory sensitivity to hypercapnia. The hypercapnic ventilatory responsiveness was measured by the Read rebreathing technique. Subjects rebreathed from a bag initially containing 7% CO_2 in

oxygen. During the HCVR test, all variables were digitally sampled at 50 Hz by a computer and averaged over four breath intervals. The HCVR was defined as the increase in minute ventilation per torr increase in PCO_2 calculated using least squares regression.

4. Respiratory Challenge Test

The purpose of this test was to determine if information from this experimental manipulation, combined with military and background psychological information (Table 5), can identify volunteers most likely to manifest adverse reactions to the CB mask. For this test, the volunteer wore the Army PT uniform and the M40 CB mask fitted with modified C2 filter canisters (empty C2 canister or denser C2 canister) to provide a range of inspiratory air flow resistance. Volunteers were evaluated on two different days. On each occasion, a volunteer breathed for 30 minutes through the M40 CB mask with minimal inspiratory resistance (filter element removed from C-2 canister) and for 30 minutes with a supra-threshold inspiratory resistance (10 cm H_2O/l/sec, attained by replacing the standard C2 filter element with a denser material). The mask resistance was "blinded" to the volunteers and all psychological personnel. This level of resistance approximated, during restful breathing, the airway pressure produced by moderate-intensity exercise hyperpnea through a standard C2 canister. This larger resistance was chosen in order to elicit measurable physiological and psychological load compensatory responses (Zechman and Wiley, 1986; Muza, 1986; Raven et al., 1979; Morgan, 1983). The order of presentation for these experimental conditions was counterbalanced across all volunteers. This procedure also involved assessment of both ventilatory parameters and psychological constructs. Ventilatory and metabolic measures (see page 11) were taken after the volunteer had been wearing the CB mask for 4 minutes and during the psychological assessment. Psychological data (Table 6) were collected from minutes 5-14 and again at minutes 20-29 to determine each volunteer's cognitive performance and subjective reactions. Specific instruments in the assessment battery are described on pages 14-15 and Appendix 2. After 30 minutes, the resistive characteristics of the mask were then changed to the other experimental condition. Again, volunteers were evaluated with the psychological assessment battery at 5-14 and 20-29 minutes into the new condition, (i.e., 35-44 and 50-59 minutes; respectively). All subjects were instructed and

practiced in the use of the psychological assessment instruments before actual data collection.

TABLE 6: QUESTIONNAIRES AND A COGNITIVE PERFORMANCE TASK FOR REPEATED ASSESSMENT DURING EACH SESSION OF THE RESPIRATORY CHALLENGE

ASSESSMENT INSTRUMENT	SUBJECT'S RESPONSE	TEST SCHEDULE	MINUTES REQUIRED
Automated Addition Task	Hand-grips	5,20,35,50 min	4
Environmental Distress Questionnaire	Verbal	9,24,39,54 min	3
Internal States Questionnaire	Verbal	12,27,42,57 min	2

5. Peak Oxygen Consumption

These studies assessed the aerobic fitness of the test volunteers and provided reference values for determining individual submaximal work rates. The $\dot{V}O_2max$ was determined by employing a continuous effort, progressive intensity, treadmill exercise protocol (Sawka et al., 1988). In this protocol, speed was held constant at either 5 or 6 mph. Initial treadmill grade was zero. Grade was increased by 2.5% every 100 sec until the volunteer reached exhaustion. Heart rate (HR) from an electrocardiogram (CM5 placement), $\dot{V}O_2$, carbon dioxide output ($\dot{V}CO_2$), and minute ventilation ($\dot{V}E$) were measured continuously throughout the exercise test. A Sensormedics Metabolic Measurement Cart was used to collect respiratory metabolic data.

6. Submaximal Exercise Test

The purpose of this test was to determine the effect of MOPP overgarments, BA and LBE on ventilation, control of breathing, pulmonary gas exchange, perception of

exertion and respiratory sensations, and cognitive performance during steady-state exercise. In this experiment, volunteers walked 100 minutes on a treadmill at an exercise intensity equal to ~600 W (~40% of the volunteer's $\dot{V}O_2max$). This intensity of aerobic exercise was chosen because it is comparable to the work intensity of many tasks performed during combat infantry operations (Goldman, 1965) and it is similar to a previous MOPP study (Cadarette, 1992) during which respiratory impairment was reported. Walking speed (3.5± 0.5 mph) and grade (0%-6%) were individually selected to elicit the desired metabolic rate. A standard U.S. Army M40 CB mask, without hood, was modified for the collection of expired gases with a metabolic measurement cart (Sensormedics MMC 2900). During the exercise bouts in mBDU, the M40 CB mask + empty C2 canister (filter element removed to minimize inspiratory resistance) was used for expired gas collection. In the mMOPP configuration, a standard C2 filter canister was used. Cardiopulmonary and metabolic parameters were measured from the volunteer during the early, mid and late phases of the exercise bout. Sampled and calculated physiological variables included the following: $\dot{V}E$, VT, f, VD/VT, VI/TI, $TI/TTOT$, $\dot{V}O_2$, $\dot{V}CO_2$, $\dot{V}E/\dot{V}CO_2$, $\dot{V}E/\dot{V}O_2$, $P_{ET}O_2$, and $P_{ET}CO_2$ (acquired by the MMC); SaO_2 (finger pulse oximeter) and HR (ECG).

In order to maintain heat strain constant between our two uniform/equipment combinations, two actions were taken. First, both uniforms were modified to increase evaporative and convective heat dissipation (no hood and shortened jacket sleeves and trousers). Second, the ambient environmental conditions were adjusted in order to obtain equivalent heat storage. Thus, when testing the modified BDU, chamber conditions were set to T_{db} 14°C, 30% rh, and T_{db} 10°C, 30% rh when testing the modified MOPP uniform. In both conditions wind velocity was 1 $m{\cdot}s^{-1}$. Thermal strain was monitored and quantified by measurement of core temperature (flexible rectal thermistor probe inserted approximately 10 cm beyond the anal sphincter) and heart rate. Since fluid loss due to sweating was predicted to be ~1.3 $l{\cdot}hr^{-1}$ for both uniform conditions, volunteers drank 400 ml of water before the start of each submaximal exercise bout to minimize deleterious effects of dehydration.

During the submaximal exercise bout, five assessment instruments were administered to evaluate the volunteer's cognitive performance and subjective reactions. The timing and frequency of these measures during the submaximal exhaustive exercise test are given in Table 7, and the method is described below.

7. Cognitive and Subjective Assessment

During each Respiratory Challenge Test and Submaximal Exercise Test, evaluations of each volunteer's cognitive performance and subjective reactions were performed (Tables 6 & 7). Two special procedures were used to permit psychological assessment while volunteers were exercising. Volunteers pressed a switch, mounted in a commercial ski-pole hand grip, as their response to a performance task or questionnaire. Responses from the volunteers were sent to a multi-channel, digital I/O board in a PC-computer, and responses were logged and scored for their **timeliness** and **accuracy**. This data base was analyzed with the Statistical Package for the Social Sciences (SPSS) and traditional descriptive and inferential statistics.

We also administered three questionnaires during each Respiratory Challenge Test and Submaximal Exercise Test: The Environmental Distress Questionnaire, the Internal States Questionnaire, and the Borg Scale. These data were collected with our "captured speech" methodology. This is a data-collection procedure used to record the verbal responses to questionnaires (or performance tasks) on audio tape for subsequent analysis (Banderet et al., 1990; Cadarette, 1992; Pimental et al., 1992). A psychology specialist orally announced items from the questionnaire or performance task to the volunteers, then paused briefly for the volunteer to announce his rating for that item. The volunteer's spoken responses were recorded on an individual channel of an audio tape for subsequent data reduction. Each volunteer wore a small tube microphone positioned inside of the M40 CB mask to facilitate high fidelity audio recordings.

a. Automated Addition Task. Volunteers performed the Automated Addition Task (Banderet et al., 1988) to evaluate cognitive capabilities. The task required rapid and accurate mental calculations, decision-making, and an action that

depends upon the decision. Addition problems and plausible sums were displayed on a large computer monitor positioned directly in front of each volunteer as he exercised on the treadmill. A computer generated a display of 36 vertical addition problems. Each problem had three 2-digit numbers and a plausible sum. The volunteer's task was to decide if each sum was "correct" or "incorrect." A volunteer indicated his decision by pushing a switch in a hand grip held in the dominant (correct) or non-dominant (incorrect) hand. The task ended after 4 minutes, and the number of problems completed during the session was displayed as feedback for the volunteer. The Automated Addition Task presents incorrect sums for 50% of the problems. Volunteers mentally calculate each problem's sum and decide if it differs from the sum given by the computer. The algorithm for generating the problems is designed so that deviations of ± 1 occur in the 100, 10, or 1-place digit of the sums on 2.5%, 45.0%, or 2.5% of all problems, respectively. Volunteers could not change their decision after they pressed a switch in one of the hand grips.

b. <u>Serial Seven's Subtraction Task.</u> Volunteers performed the Serial Seven's Subtraction Task. This second measure of cognitive performance also created reproducible, oral responses during performance of this task. The psychology specialist called for everyone's attention, then gave a three-digit number (e.g., "963"). As soon as the specialist gave the number, the volunteer subtracted 7 from it and continued subtracting 7 from each subsequent remainder until told to stop. Volunteers were instructed to respond as quickly and accurately as possible. After 3 minutes, the Serial Seven's Subtraction Task ended.

c. <u>Environmental Distress Questionnaire.</u> The Environmental Distress Questionnaire (Appendix 2) is an abbreviated version of the original Environmental Symptoms Questionnaire (Sampson et al., 1983; Shukitt et al., 1990). This questionnaire consists of 24 of the original 67 items combining all items from The General Distress Index (Munro et al., 1986) and The Subjective Heat Illness Index (Johnson and Merullo, 1992). The General Distress Index predicts soldiers who are less likely to complete a stressful challenge in MOPP IV (Munro et al., 1986).

The Subjective Heat Illness Index quantifies the effects of heat and dehydration (Derogatis, 1983). In the present study, high ambient heat and dramatic increases in body temperature were not created. Thus, many of the "heat" items served as positive controls and diverted the volunteer's attention from some items of greater interest to us.

d. **Internal States Questionnaire.** The Internal States Questionnaire (Appendix 2) consists of 28 items for assessing subjective reactions to ventilation. Items reflecting both pleasant and aversive effects were incorporated to minimize response bias and stereotypy (Banderet et al., 1990). This questionnaire uses a 6-point rating scale with discrete-anchor points that is the same as that used with the Environmental Distress Questionnaire and the original Environmental Symptoms Questionnaire.

e. **Borg Scale.** The volunteers were asked to rate their perception of exertion using the 16-point Borg Scale (Borg, 1973).

Volunteers practiced for ~45 minutes on three separate occasions during the first 2 days of the study. We gave the questionnaires 1-2 times and the performance tasks 12 times. During the second and third occasions for practice, we gave each volunteer feedback on his performance. Extensive practice with the cognitive performance tasks was required so that the sensitivity (power) of these dependent measures was maximal and assessment of performance was not confounded with acquisition effects (Banderet et al., 1988; Carter et al., 1981). Because this was a repeated-measures experimental design, alternate but equivalent forms of the Automated Addition Task were administered and different, random numbers between 950-999 were used to start the Serial Seven's Subtraction Task. Finally, to train our computer-based speech recognition device, each volunteer was asked to say the digits 0-5 and a few other critical "response" words 1-3 times while wearing the CB mask, exercising, and/or remaining sedentary.

TABLE 7: QUESTIONNAIRES AND COGNITIVE PERFORMANCE TASKS ADMINISTERED REPEATEDLY DURING EACH SESSION OF THE SUBMAXIMAL EXERCISE TEST

ASSESSMENT INSTRUMENT	SUBJECT'S RESPONSE	TEST SCHEDULE	MINUTES REQUIRED
Automated Addition Task	Hand-grips	8,80 min	4
Environmental Distress Questionnaire	Verbal	12,84 min	3
Internal States Questionnaire	Verbal	15,87 min	3
Borg Perceived Exertion Scale	Verbal	17,88 min	.5
Serial-Seven's Subtraction	Verbal	18,90 min	3

8. Data Analysis

Standard repeated measures analysis of variance were used to determine the effect of time and mMOPP uniform levels on physiological and psychological variables. Significant main effects and interactions were explored using standard post hoc tests (i.e., Tukey's critical difference). All data from each cognitive performance task were converted to a single performance measure that reflects the combined effects of timeliness and accuracy (Banderet et al., 1988). We also adjusted the number of errors on the Automated Addition Task to penalize for possible guessing.

RESULTS

PULMONARY FUNCTION TESTS

The measurement of pulmonary function and chest wall displacement provided a quantitative assessment of the respiratory load produced by wear of each uniform combination. Compared to the PT uniform (baseline condition), the mMOPP uniform configuration decreased Maximal Voluntary Ventilation (MVV) by about 25% (Fig. 1,

Table 8). The PC+BA+LBE produced ~5% of this reduction, and the CB mask ~20%. As expected, the M40 CB mask significantly decreased respiratory flows (FIF50% and FEF50%) and had little impact on lung volumes (TLC and FVC) as in Table 8 and Fig 2. On the other hand, the PC+BA+LBE significantly decreased lung volumes and had negligible effect on airflow.

TABLE 8: EFFECT OF NBC EQUIPMENT, BODY ARMOR AND LBE ON RESTING PULMONARY FUNCTION

PFT VARIABLE	PTU	mBDU + CB Mask with standard C2 Filter canister	mMOPP (PC+BA+LBE)
FVC (l)	5.73±0.90	5.66±0.91	5.45±0.83*†
FEV_1 (l)	4.65±0.67	4.45±0.69	4.36±0.77*
FEV_1 /FVC	0.82±0.07	0.79±0.08	0.80±0.07
FEF50% (l/s)	5.95±1.51	5.20±1.76	5.09±1.45*
FIF50% (l/s)	7.38±1.89	5.39±0.78*	5.27±0.94*
FEF50%/FIF50%	0.84±0.24	0.95±0.24	0.97±0.26
PEF (l/s)	8.96±1.30	7.86±1.92*	7.87±1.65*
PIF (l/s)	7.91±1.64	5.71±0.73*	5.63±1.06*
MVV (l/min)	188.9±26.0	147.5±24.1*	139.5±25.5*
TLC (l)	7.66±1.34	7.61±1.23	7.25±1.22*†
RV (l)	1.93±0.89	1.96±0.73	1.81±0.72
FRC (l)	2.96±0.77	3.09±0.65	2.83±0.60

P<0.05: * vs. PTU; † vs. mBDU

The decreased lung volumes were likely the result of the "corset-like" nature of the PC+BA+LBE uniform combination on the chest wall. Accordingly, we found that total respiratory system compliance (Crs) was decreased ~16% in the mMOPP uniform

combination compared to the mBDU (Fig. 3). Thus, the wear of the PC+BA+LBE increased the "stiffness" of the soldier's respiratory system.

SUBMAXIMAL EXERCISE CARDIOPULMONARY RESPONSES

The submaximal exercise tests determined the effect of MOPP overgarments, BA and LBE on ventilation, control of breathing, pulmonary gas exchange, cognitive performance and subjective reactions during sustained physical work. All test volunteers were able to complete 100 minutes of treadmill walking at a metabolic rate of ~610 W in both the mBDU and mMOPP uniforms. In both uniform configurations $\dot{V}O_2$ was identical, averaging 1.78±0.08 and 1.74±0.15 $l \cdot min^{-1}$ over the exercise period in the mBDU and mMOPP uniforms, respectively. As shown in Table 9, our goal of minimizing and equalizing heat strain between the two uniform combinations was also achieved. During the 100 minutes of treadmill exercise, Tre increased by only ~1 °C in both uniforms. Therefore, a key condition of the experimental design was achieved: metabolic intensity and thermal strain were identical between the two uniform configurations. This permited analysis of the effect of the mMOPP garment, M40 CB mask, BA and LBE on the pattern and mechanics of breathing during sustained submaximal exercise independent of heat strain.

TABLE 9: RECTAL TEMPERATURE (C°) DURING 600 W SUBMAXIMAL EXERCISE

uniform	0 min	10 min	20 min	30 min	40 min	60 min	80 min	100 min
mBDU	36.9±0.3	37.1±0.2	37.4±0.2	37.6±0.2	37.8±0.2	37.8±0.1	37.8±0.3	37.7±0.4
mMOPP	37.0±0.2	37.2±0.1	37.4±0.1	37.6±0.2	37.7±0.1	37.8±0.2	37.8±0.2	37.9±0.2

Minute ventilation, measured in the early, mid and late phases of each submaximal exercise test, did not significantly change over the period of the exercise. As illustrated in Fig. 4, exercise minute ventilation was approximately 45 $l \cdot min^{-1}$ during the submaximal exercise tests and the same in both uniform combinations. However, tidal volume was significantly ($p<0.05$) smaller and respiratory rate significantly greater when wearing the mMOPP uniform compared to the mBDU. Although these differences were

small for the group, intersubject variability was large, as illustrated in Figures 5 and 6. Nearly 25% of the subjects dropped their exercise minute ventilation by more than 10% in the mMOPP uniform compared to the mBDU. All subjects demonstrated a decrease in exercise tidal volume in the mMOPP compared to mBDU uniforms (Fig 5B), with a third experiencing more than a 10% decline. Respiratory rate responses in mMOPP varied more ranging from 85% to 135% of the mBDU values (Fig 5C). Analysis of the respiratory duty cycle (Ti/TOT, Fig. 6A) and mean inspiratory flow rate (Vt/Ti, Fig. 6B) did not disclose any consistent response. However, respiratory rate appeared to increase due to decreases of both inspiratory (Ti) and expiratory (Te) durations (Fig. 6).

Breathing Reserve (BR) was significantly decreased ($p<0.01$) in the mMOPP uniform compared to the mBDU (Fig. 7). Breathing Reserve varied greatly among the test subjects (Fig. 8). In the mBDU during the submaximal exercise, 50% of the subjects had a BR>145 $l \cdot min^{-1}$, where as in the mMOPP uniform configuration, the median decreased to 100 $l \cdot min^{-1}$. In 50% of the subjects, BR decreased more than 40%. Since exercise ventilation was not different between the two uniform configurations, the decreased BR results from the decreased maximal ventilatory capacity described earlier.

Alveolar gases (PAO_2 101±5, $PACO_2$ 41±4 mmHg) were similar in both the mBDU and mMOPP and did not significantly change as a function of exercise duration.

Exercise heart rate was greater ($p<0.02$) in the mMOPP (126±12 $b \cdot min^{-1}$) compared to the mBDU (122±9 $b \cdot min^{-1}$) uniforms. Likewise, subjects consistently rated their overall perception of effort (RPE, Table 10) greater ($p<0.05$) in the mMOPP than mBDU). Furthermore, in both uniforms RPE increased ($p<0.05$) with the duration of exercise.

TABLE 10: RATED PERCEPTION OF EFFORT (RPE) DURING 600 W SUBMAXIMAL EXERCISE

Uniform	20 min	90 min
mBDU	10.6±1.8	12.8±1.8
mMOPP	11.5±2.0	13.7±2.2

Volunteers performed the Serial Seven's Subtraction Task to measure cognitive performance and create reproducible, oral responses. As illustrated in Fig. 9, during the 3-minute speech task, minute ventilation was reduced compared to the steady-state exercise ventilation. The hypoventilation was most apparent and statistically significant ($p<0.05$) during the first minute of the speech task, achieving ~11% reduction in minute ventilation. Furthermore, upon cessation of the speech task, minute ventilation tended to increase above steady-state levels, although this was not statistically significant. The effects of a speech task on exercise ventilation were identical in both the mBDU and mMOPP uniform combinations.

SUBMAXIMAL EXERCISE SUBJECTIVE REACTIONS

The uniform type (mMOPP vs. mBDU) or the duration of exercise significantly increased many symptoms and adverse effects as measured by the Internal States Questionnaire (Table 11) and the Environmental Distress Questionnaire (Table 12). Many such significant effects were attributable to the simple (additive) effects of the uniform or the duration of exercise as shown in Figures 10-14. In these figures, the control value was obtained from subjects on a different day while they were sedentary and wearing the M40 CB mask. In a few instances, interactive (multiplicative) effects were found. An interactive effect measured during submaximal exercise with the Internal States Questionnaire was "I am uncomfortable" (item 28). Figure 12 shows the aversive, interactive effects of the mMOPP uniform and exercise duration on this item. This was the only interactive effect statistically significant measured by the Internal States Questionnaire (Table 11). Figure 14 shows that subjects were sickest after 13 min of exercise and wearing mMOPP, where as subjects wearing mBDU were sickest only after

85 min of exercise. This was the only interactive effect measured by the Environmental Distress Questionnaire that was statistically significant (Table 12). Except for the interactions, mMOPP and greater durations of exercise resulted in increased symptoms and perceived averseness for all items on the questionnaire that were statistically significant.

Figure 13 shows data for the measure of subjective heat illness derived from selected items in the Environmental Symptoms Questionnaire (Sampson et al., 1983; Shukitt et al., 1990). Heat illness scores increased significantly with exercise duration, but were not affected by uniform type, further substantiating our goal of maintaining thermal strain as equal between the two uniform configurations.

RESPIRATORY CHALLENGE TEST

All volunteers completed each 60-minute test, seated wearing the M40 CB mask, with minimal or elevated inspiratory resistance. No measurable differences were found between the two resistance levels in the subject's ventilatory, cognitive performance or subjective reactions.

TABLE 11. INTERNAL STATES QUESTIONNAIRE: STATISTICAL SIGNIFICANCE OF EFFECTS ATTRIBUTABLE TO THE mMOPP, EXERCISE DURATION, OR THE INTERACTION OF THE mMOPP AND EXERCISE DURATION

	Statistically Significant Effects		
Items from the Internal States Questionnaire	**mMOPP**	**Duration**	**Interaction**
1. I feel "claustrophobic."			
2. I can [not] easily exhale the air from my lungs.	+	+	
3. I feel anxious.	+		
4. My lungs hurt.		+	
5. I think I can [not] "get thru" these conditions for an additional 30 minutes or more.		+	
6. I [do not] feel "great."		+	
7. I feel I can not continue much longer.			
8. I [do not] feel as good as I usually feel.	+	+	
9. I feel tense.			
10. My chest feels like it does when I have a cold or infection.		+	
11. My mental activities and bodily movements are [not] well coordinated.		+	
12. My vision is not as good as usual.			
13. When I breathe, I feel like I can not get enough air.	+		
14. I [do not] like this experience.			
15. It feels like I have "butterflies in my stomach."			
16. I am [not] breathing the way I usually do.	+		
17. I am [not] relaxed.	+		
18. This condition requires extra effort to breathe.	+	+	
19. I feel "tingling" on some parts of my body.		+	
20. I am [not] coping well with these conditions.	+	+	
21. I am [not] "in touch" with the different parts of my body.			
22. It is hard to get my body to do what I want.			
23. This situation [does not] seem easy enough to endure.		+	
24. My memory and attention are [not] functioning as well as usual.			
25. It feels like I can not breathe fast enough.			
26. I [do not] like these conditions.			
27. I feel like I'm suffocating.		+	
28. I am uncomfortable.			+

Each "+" indicates statistical significance at $p < 0.05$. Significant items indicate that mMOPP produced greater aversive changes than mBDU, greater exercise durations increased stressful effects, or that the interaction of these effects was significant. Items that are italicized yielded effects attributable only to the type of uniform.

TABLE 12. ENVIRONMENTAL DISTRESS QUESTIONNAIRE: STATISTICAL SIGNIFICANCE OF EFFECTS ATTRIBUTABLE TO THE mMOPP, EXERCISE DURATION, OR THE INTERACTION OF THE mMOPP AND EXERCISE DURATION

	Statistically Significant Effects		
Items from the Environmental Distress Questionnaire	Uniform	Duration	Interaction
1. I feel lightheaded.		+	
2. I have a headache.		+	
3. I feel dizzy.		+	
4. I feel faint.			
5. My coordination is off.			
6. I'm short of breath.		+	
7. It's hard to breathe.		+	
8. It hurts to breathe.		+	
9. My heart is beating fast.	+	+	
10. I have muscle cramps.		+	
11. I have stomach cramps.			
12. I feel weak.		+	
13. I feel sick to my stomach (nauseous).			
14. I'm constipated.			
15. I feel warm.			+
16. I'm sweating all over.	+	+	
17. Parts of my body feel numb.	+	+	
18. My vision is blurry.			
19. I've lost my appetite.			
20. I feel sick.			+
21. I'm thirsty.		+	
22. I feel tired.		+	
23. I feel irritable.			
24. I feel restless.		+	

Each "+" indicates the effect was statistically significant at $p < 0.05$.

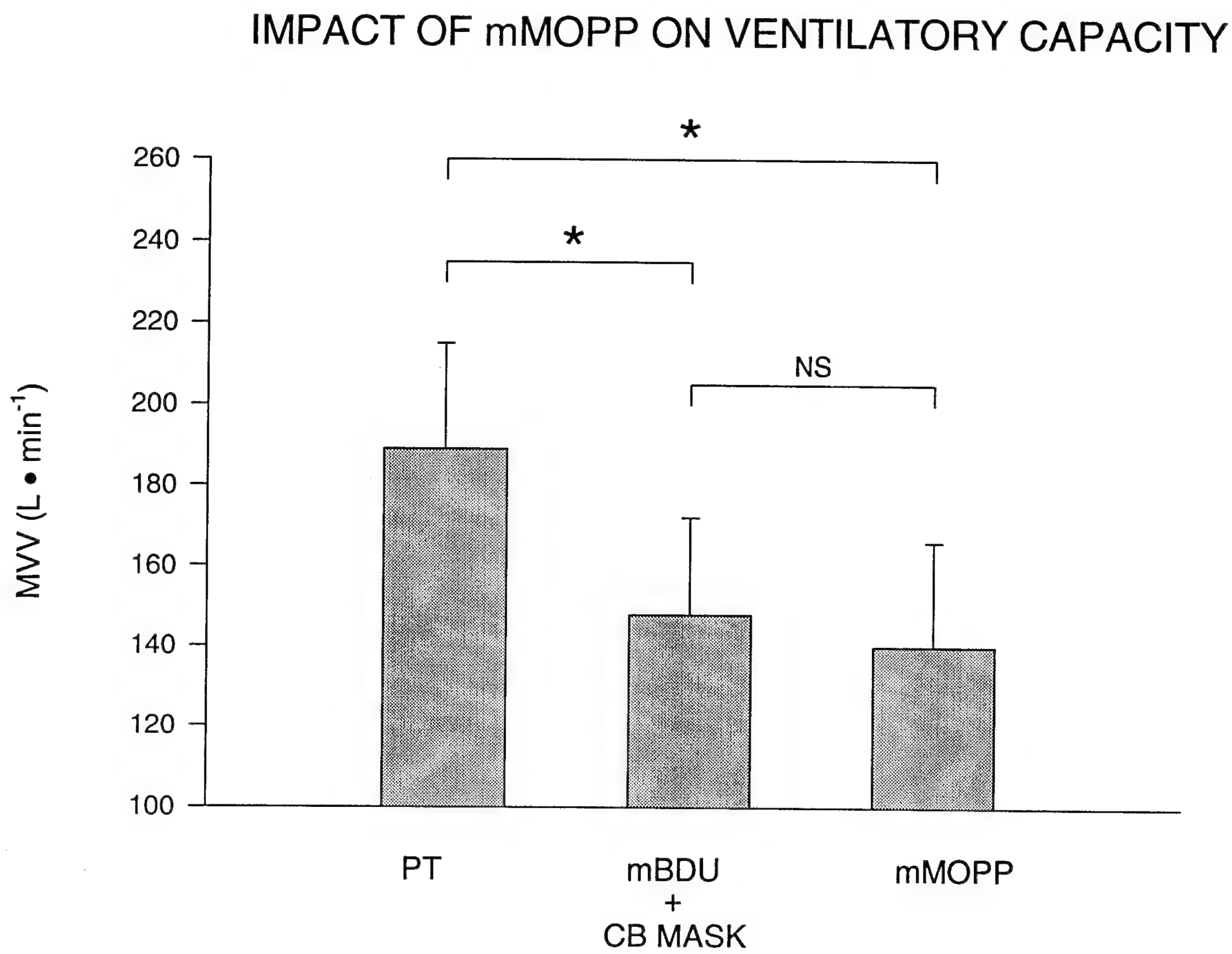

Figure 1. Effect of mMOPP uniform components on maximal ventilatory capacity (MVV).

mMOPP IMPACT ON RESPIRATORY FUNCTION

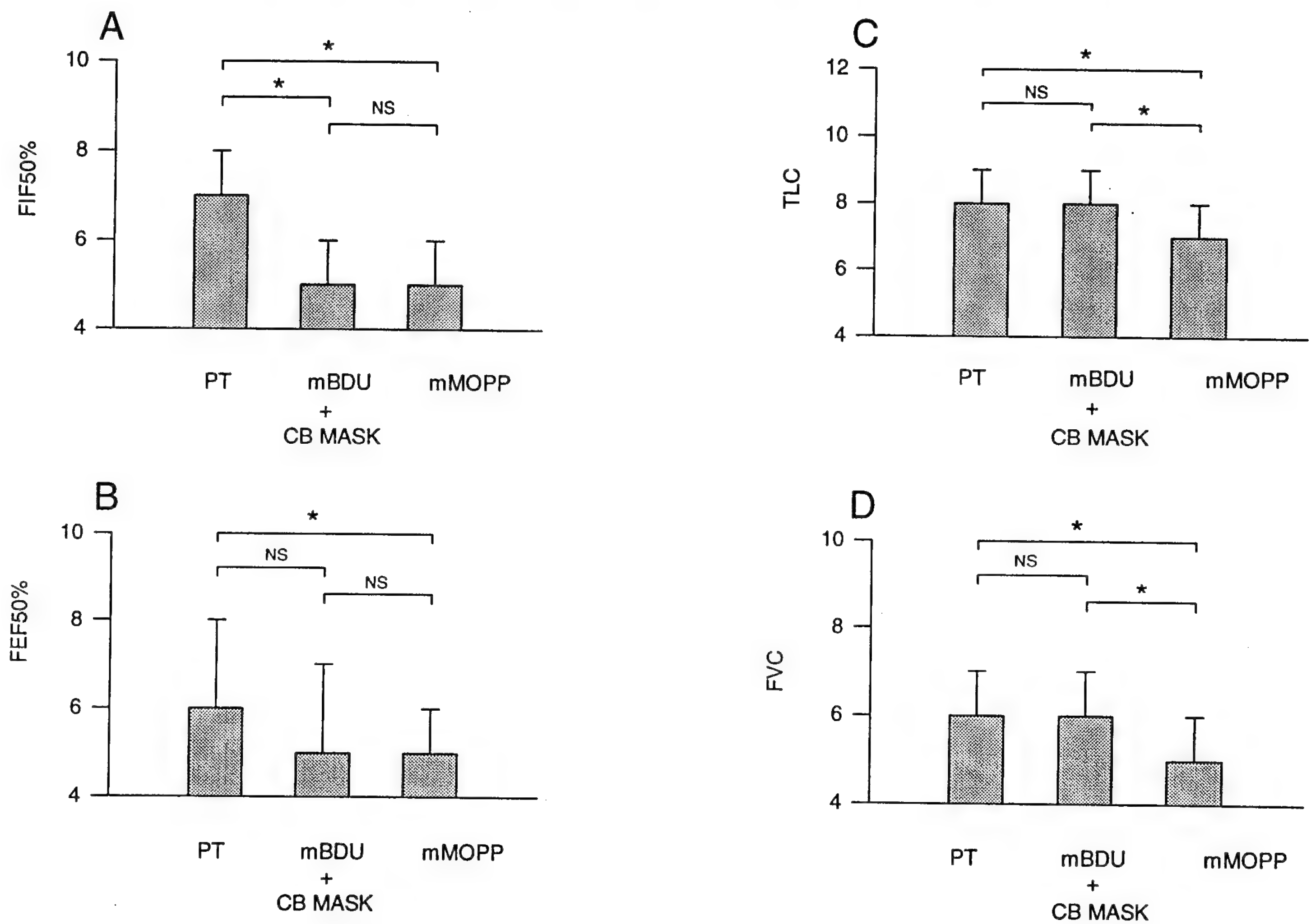

Figure 2. Effect of mMOPP ensemble components on respiratory flows (FIF 50% and FEF 50%) and volumes (TLC and FVC).

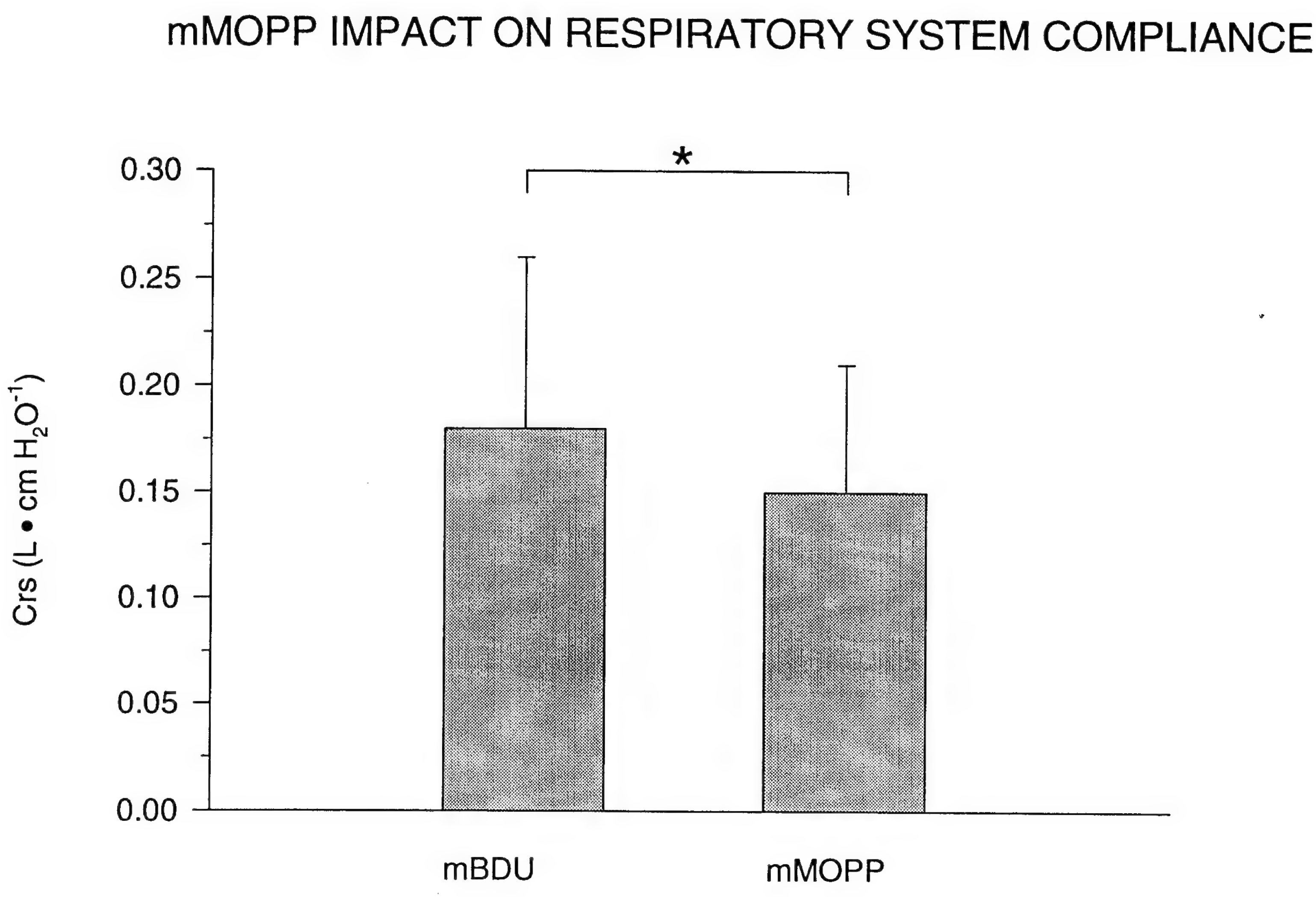

Figure 3. Total respiratory system compliance.

mMOPP IMPACT ON EXERCISE VENTILATION

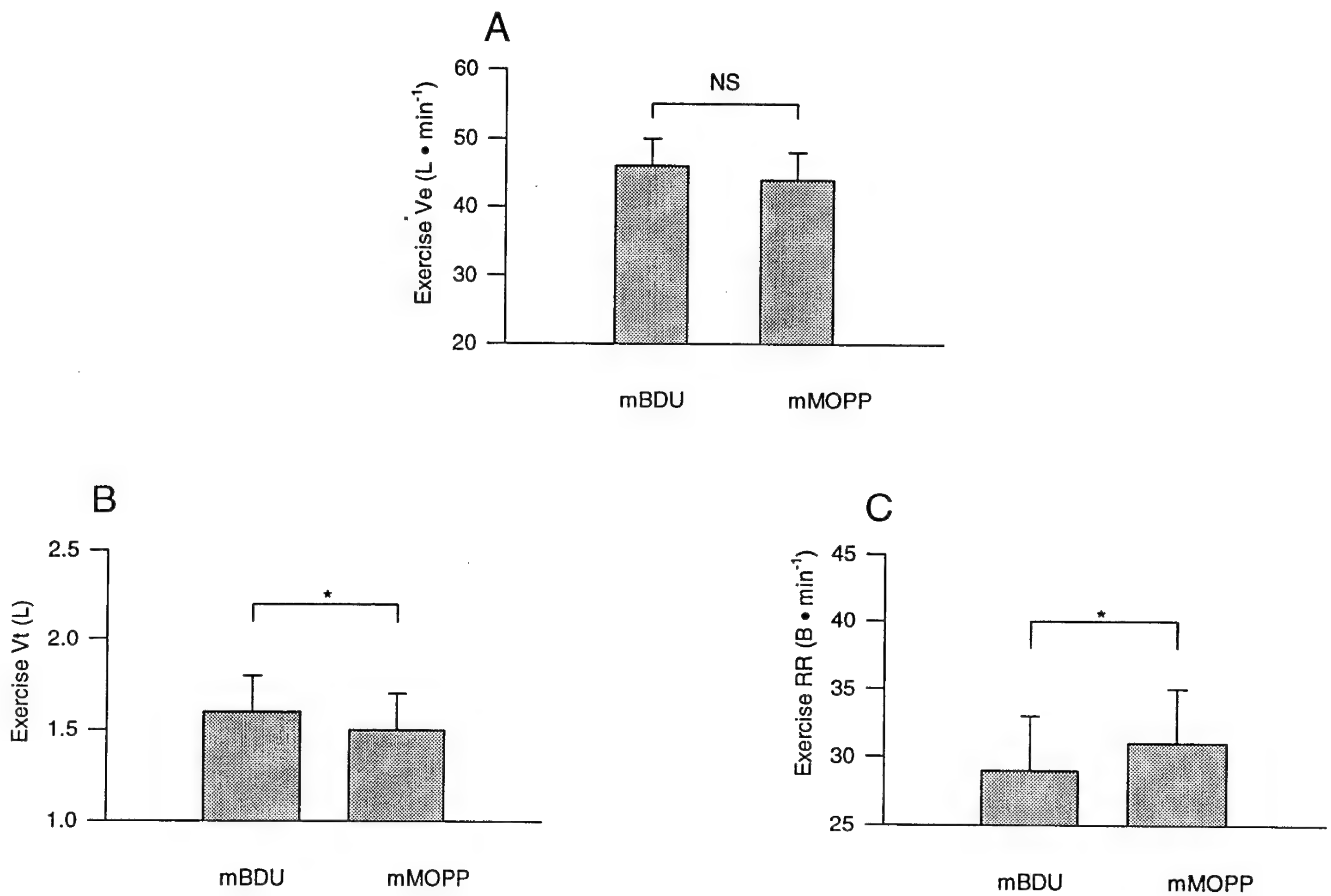

Figure 4. Ventilatory response during submaximal (~600 W) treadmill exercise in the mBDU and mMOPP uniforms.

mMOPP IMPACT ON EXERCISE VENTILATION

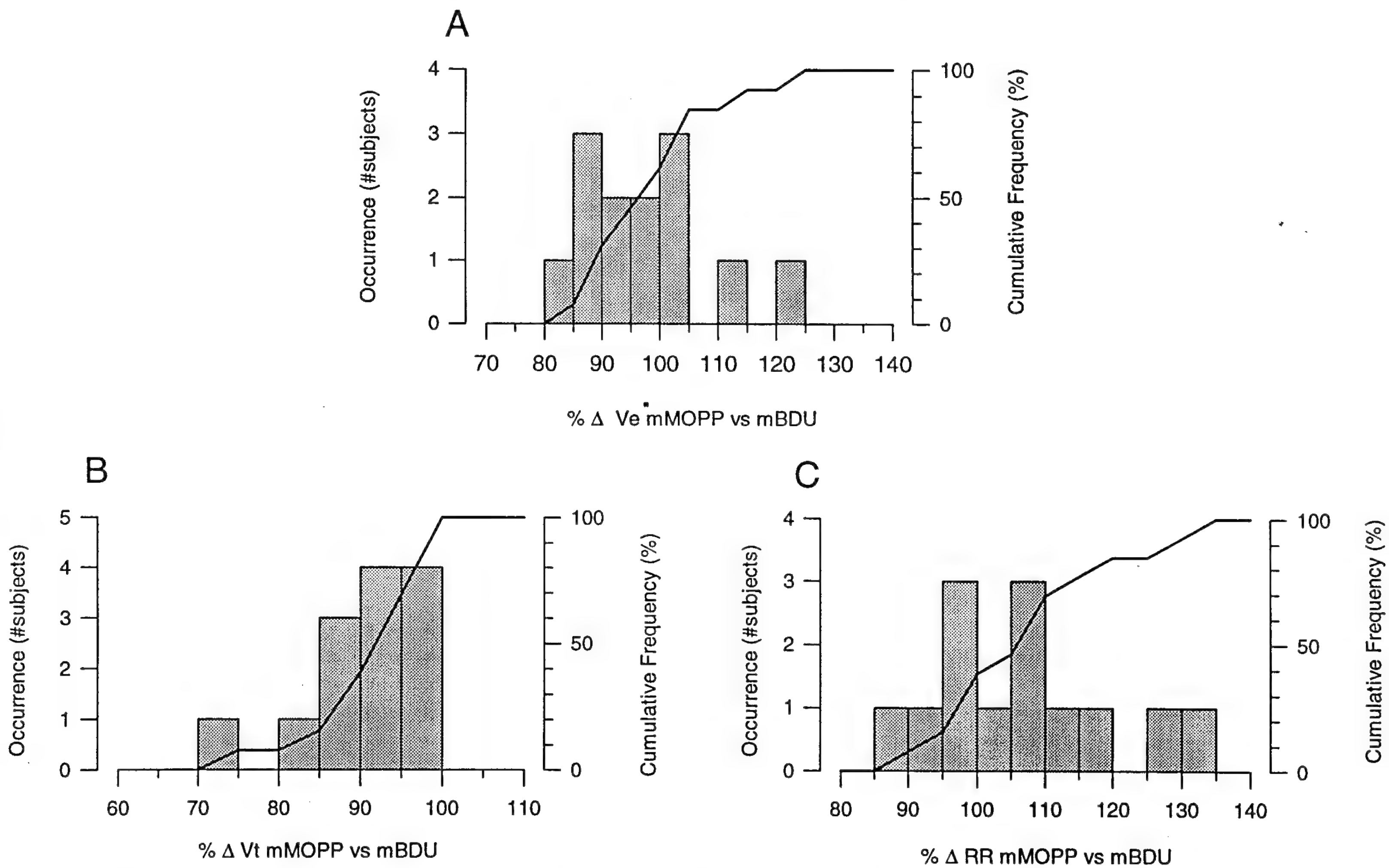

Figure 5. Distribution of exercise ventilatory responses in the mMOPP compared to mBDU uniforms. No change between uniform configurations is represented as 100% Δ. Cumulative frequency is shown by solid line.

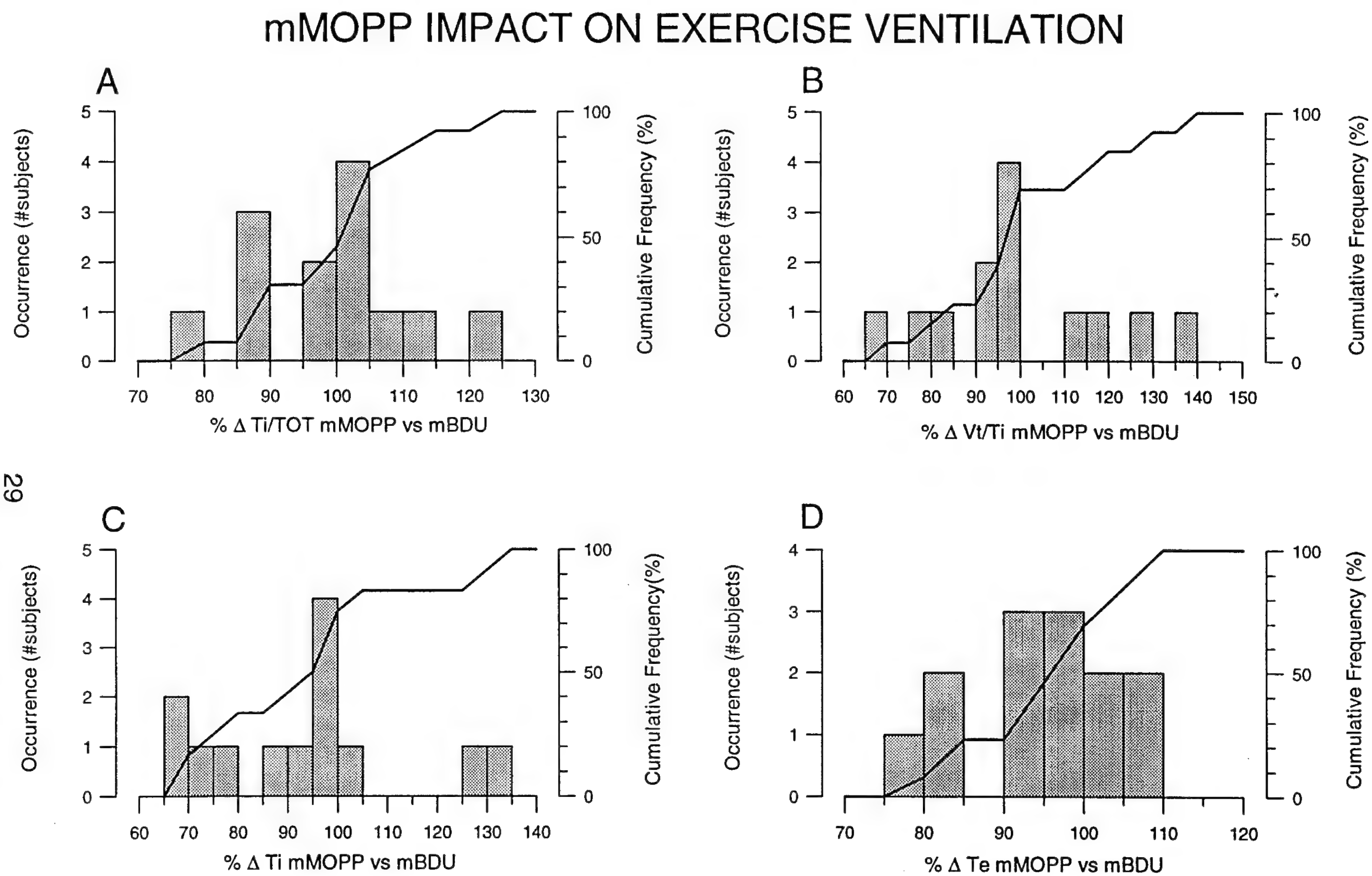

Figure 6. Distribution of exercise pattern of breathing in the mMOPP compared to the mBDU uniforms. No change between uniform configurations is represented as 100% Δ. Cumulative frequency is shown by solid line.

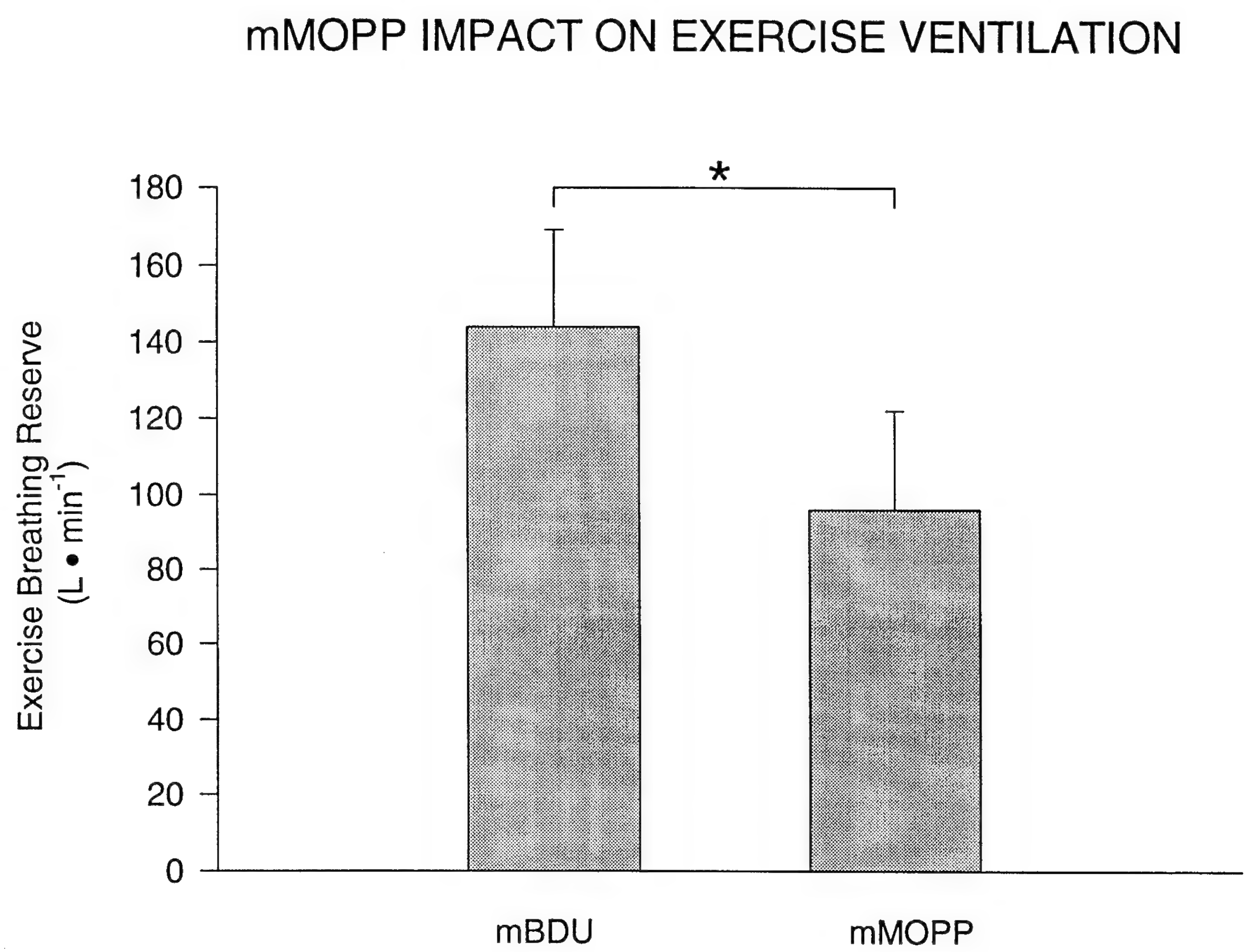

Figure 7. Breathing reserve (MVV-$\dot{V}e$) during submaximal (~600 W) treadmill exercise in the mBDU and mMOPP uniforms.

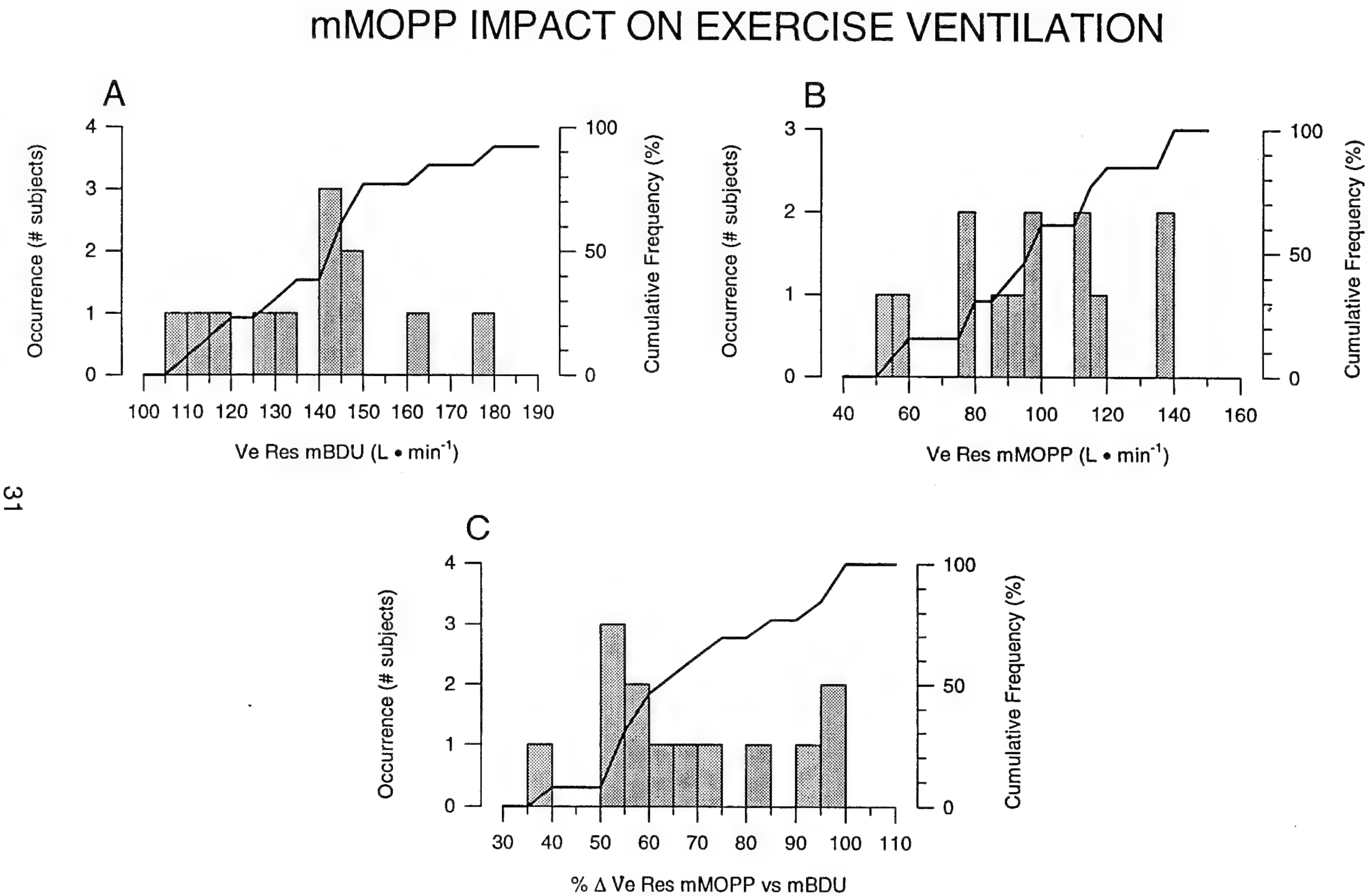

Figure 8. Distribution of exercise ventilatory reserve in the mBDU (A) and mMOPP (B) uniforms and the % Δ in breathing reserve (C) in the mMOPP compared to the mBDU uniforms. No change between uniform configurations is represented as 100% Δ. Cumulative frequency is shown by the solid line.

EFFECT OF A SPEAKING TASK ON EXERCISE VENTILATION

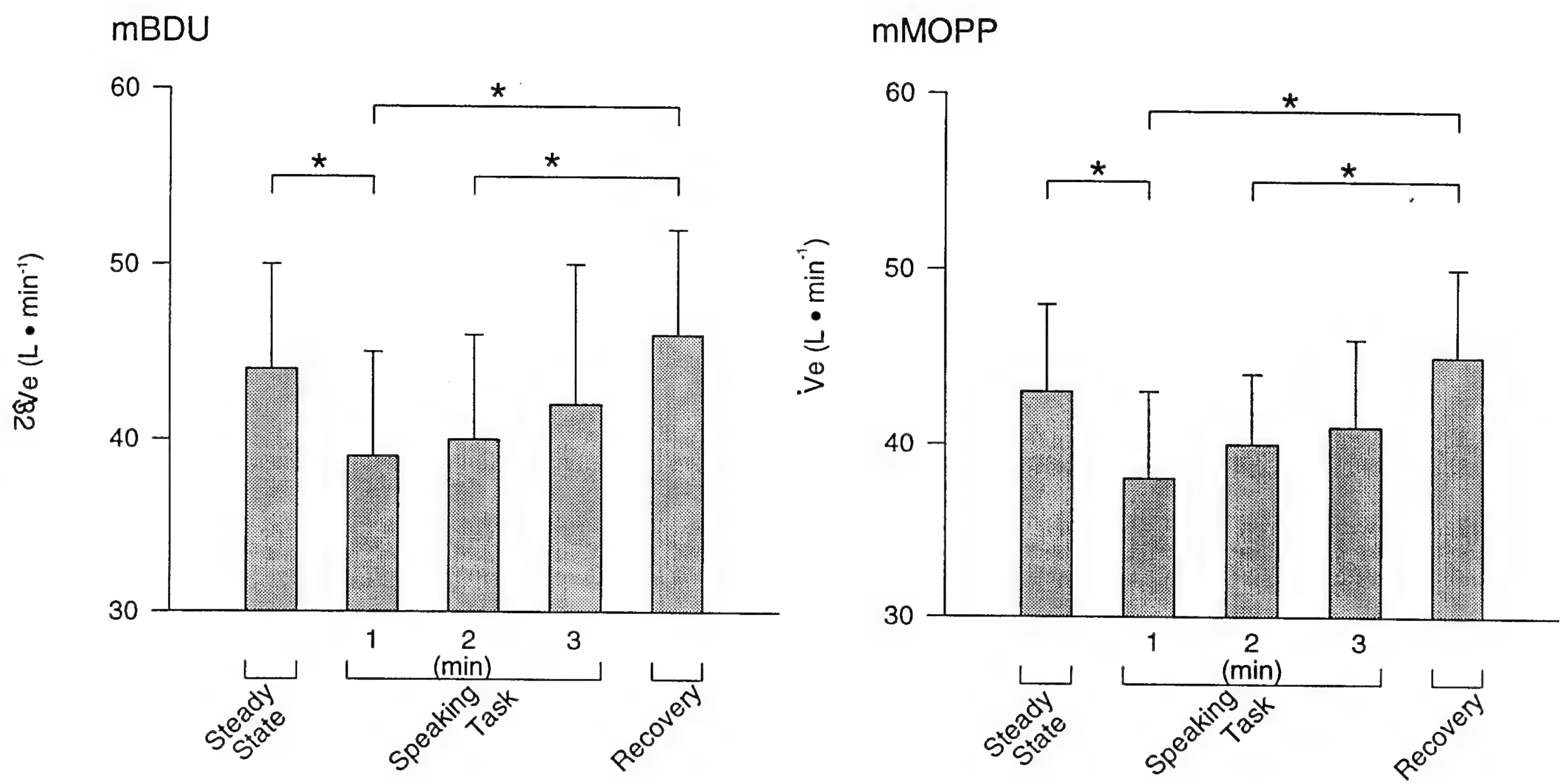

Figure 9. Exercise ventilation response to imposition of a 3-minute cognitive speaking task. Recovery was measured during the first minute after cessation of speech task.

mMOPP IMPACT ON EXERCISE VENTILATION

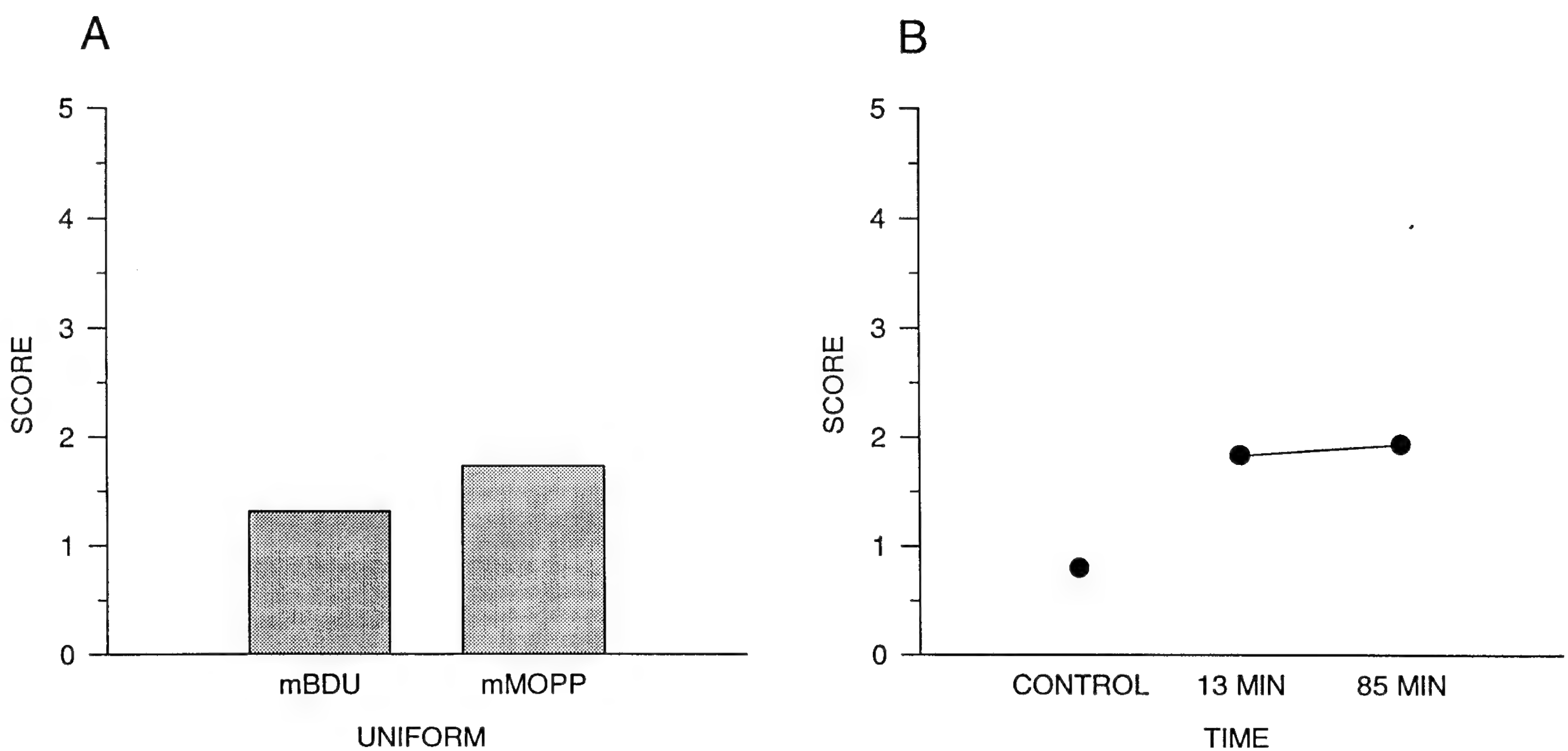

Figure10. Effort to breath measured during submaximal exercise with the ISQ item 18, "This condition requires extra effort to breath". Aversive effect of the mMOPP uniform compared to mBDU (A) and the same effects attributable to exercise duration (B).

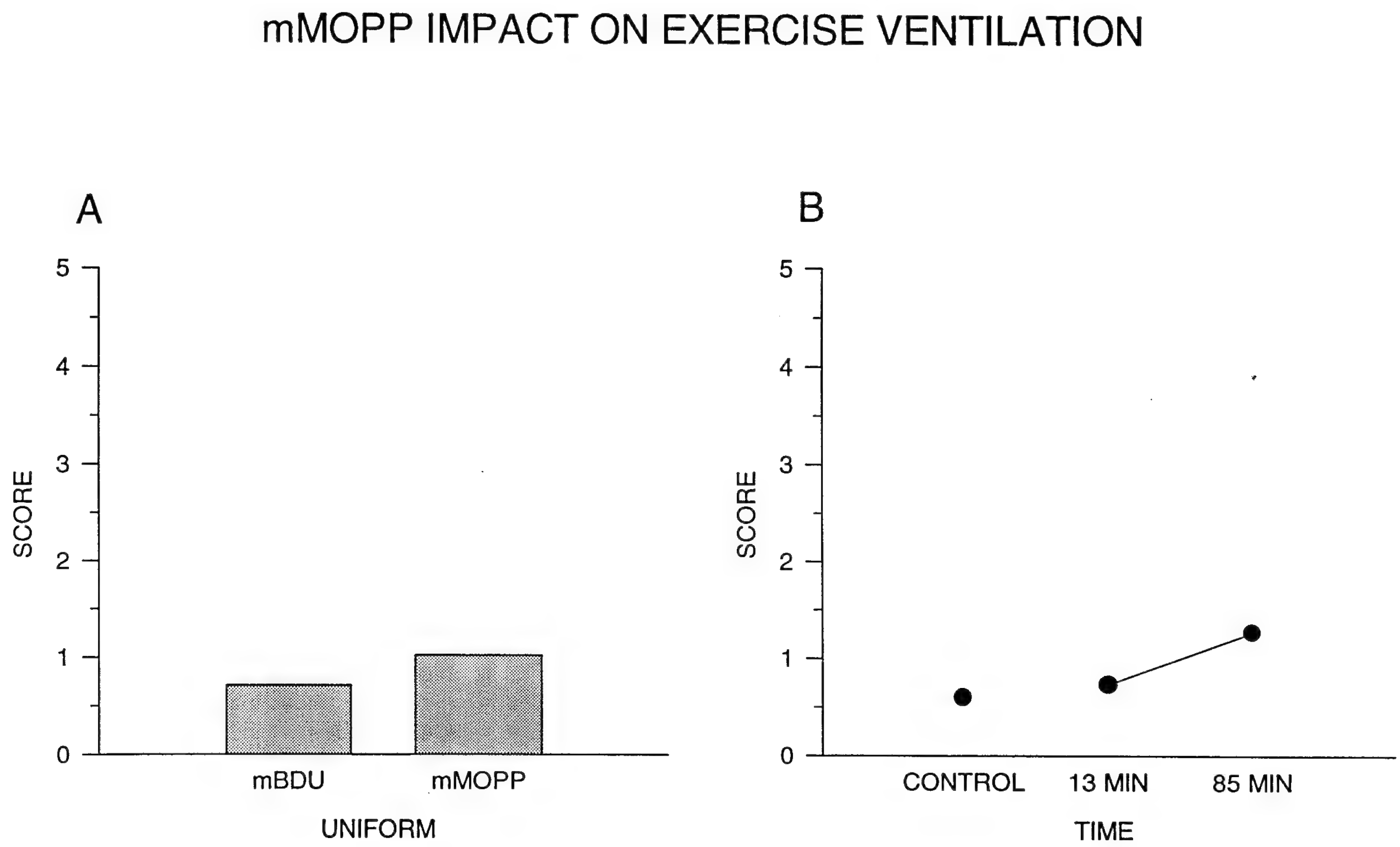

Figure 11. Ability to cope measured during submaximal exercise with the ISQ item 20, "I am coping well with these conditions". Aversive effect of the mMOPP uniform compared to mBDU (A) and and the same effects attributable to exercise duration (B).

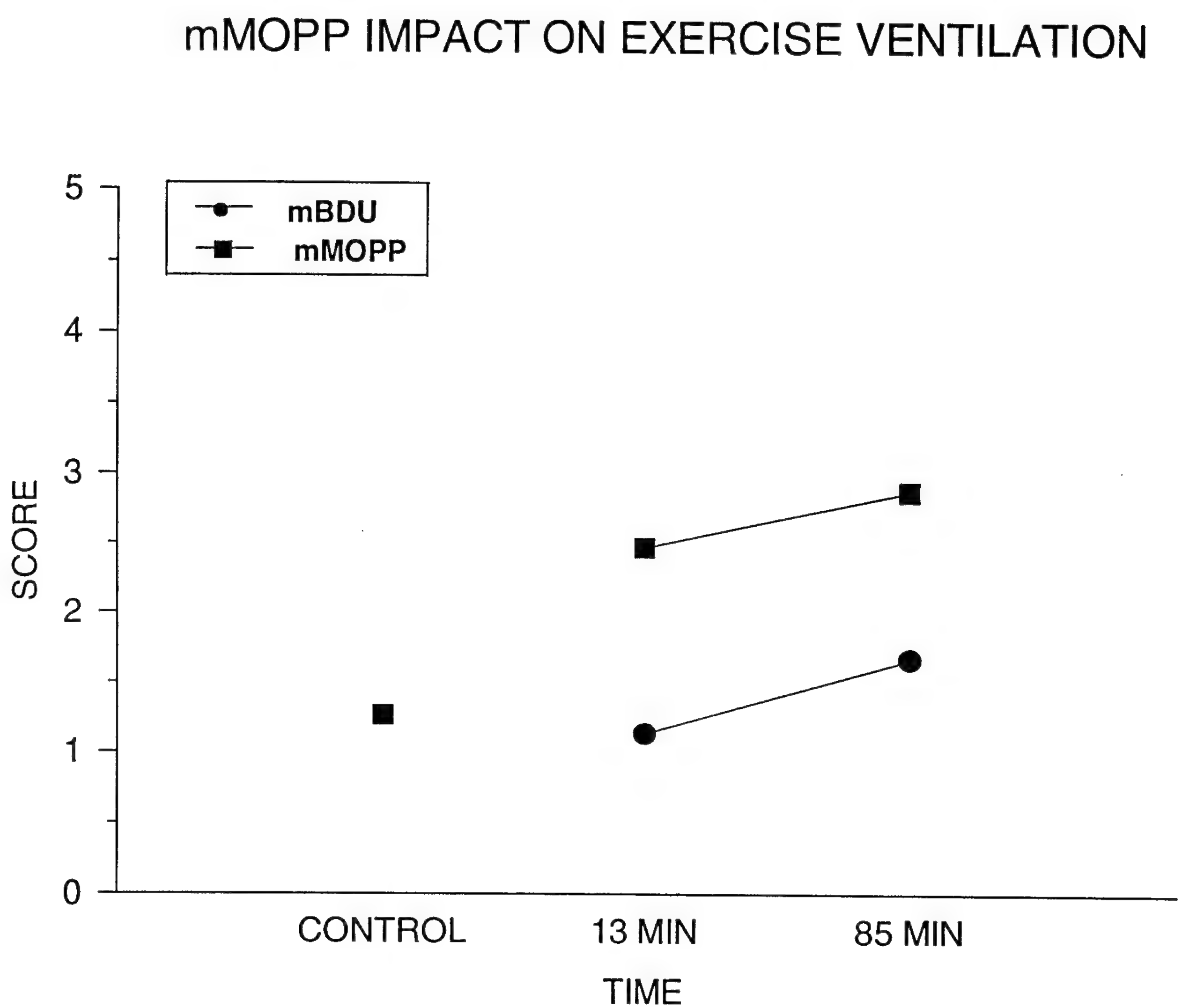

Figure 12. Degree of comfort measurerd during submaximal exercise with the ISQ item 28, "I am uncomfortable". Interactive effects of mMOPP uniform and exercise duration.

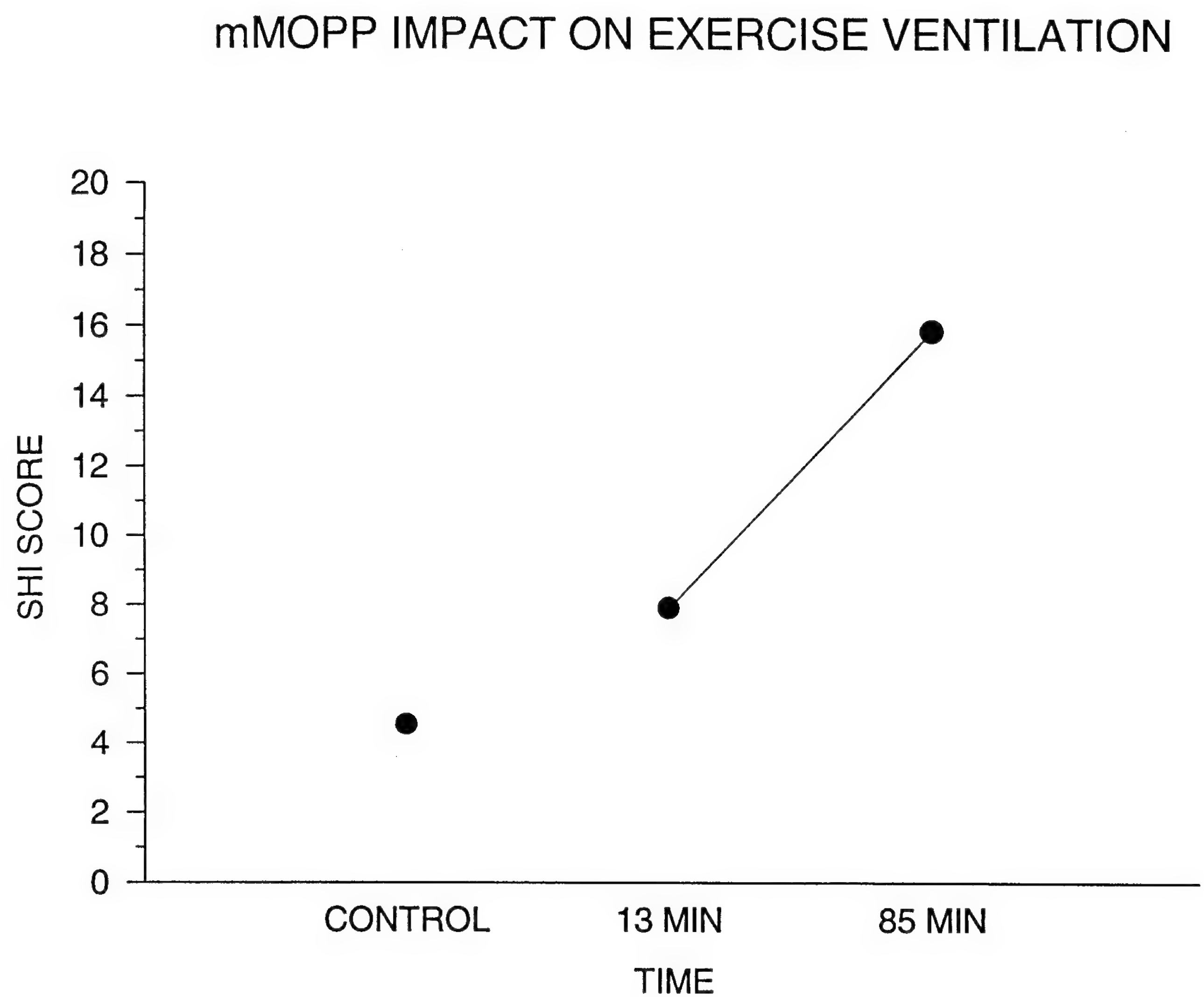

Figure 13. Subjective heat illness measured during submaximal exercise with the EDQ. There was no aversive effect of the mMOPP uniform compared to the mBDU.

mMOPP IMPACT ON EXERCISE VENTILATION

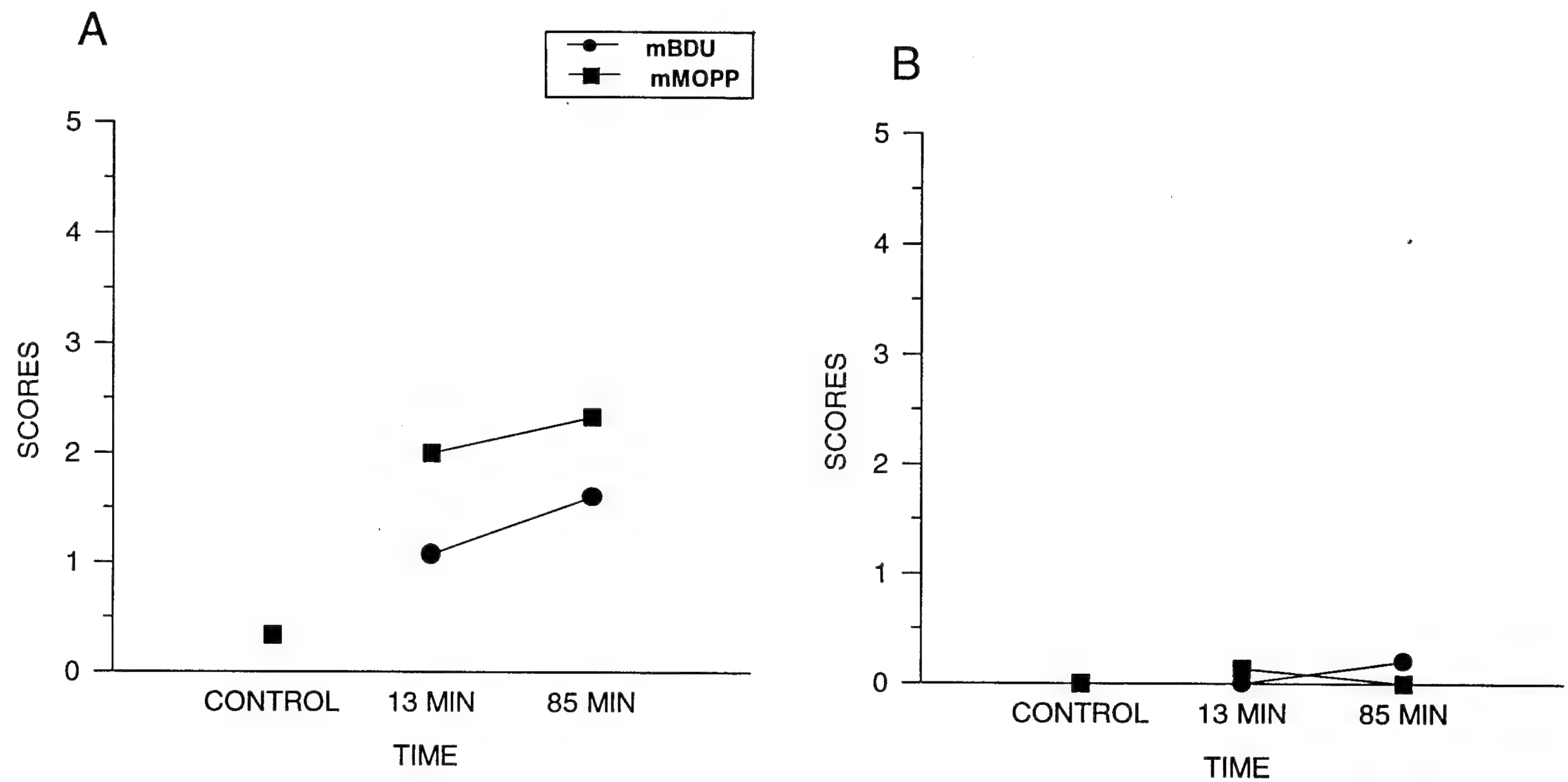

Figure 14. Symptoms of warmth and sickness measured during submaximal exercise with (A) EDQ item 15: "I feel warm" and (B) item 20, "I feel sick". Aversive and interactive effects attributable to the mMOPP uniform and exercise duration.

DISCUSSION

This study tested the hypothesis that the NBC overgarment, in conjunction with a fighting load (BA and LBE), presents a unique external constraint on the chest wall separate from that imposed by the CB Mask. Furthermore, this restriction of chest wall motion contributes to the impairment of breathing during performance of physical work in mMOPP. We also tested the hypothesis that imposing a verbal task during exercise decreases ventilation. Concurrent with these impairments to physiological function, we hypothesize that increasingly stressful conditions will produce greater adverse effects on psychological functions (more intense symptoms, less positive emotion, and impaired performance). Furthermore, the combination of these challenges may aggravate the development of adverse respiratory sensations, thus the perceived exertion of the physical work task. The results of this study support these hypotheses.

The measurement of pulmonary function and chest wall displacement provided a quantitative assessment of the respiratory load produced by wear of each uniform combination. Compared to the PT uniform (baseline condition), the mMOPP uniform configuration decreased MVV by about 25%, with ~one-fifth of this reduction attributed to the external load (PC+BA+LBE) on the chest wall. Although many factors influence MVV, it is basically the product of respiratory rate and tidal volume. Respiratory rate is largely governed by the flow-resistive properties of the respiratory system, whereas tidal volume is dependent upon respiratory system elastance. As expected, the M40 CB mask significantly decreased respiratory flows and had little impact on lung volumes. On the other hand, as hypothesized, the PC+BA+LBE significantly decreased lung volumes and had negligible effect on airflow. The decreased lung volumes were likely the result of the "corset-like" nature of the mMOPP uniform combination on the chest wall. Accordingly, we found that total respiratory system compliance was decreased by ~16% in the mMOPP uniform combination compared to the mBDU. Thus, wearing the PC+BA+LBE components increased the "stiffness" of the soldier's respiratory system, decreasing maximal ventilatory capacity and increasing the work of breathing. The magnitude of this elastic load on the chest wall created by PC, BA and LBE was not known prior to this study.

The effects of the mMOPP uniform configured with a fighting load on respiratory function are consistent with results of previous studies that found that LBE systems worn over the BDU reduce maximum breathing capacity by ~10% (Muza et al., 1989; Quigley et al., 1993; Legg, 1988; Legg and Mahanty, 1985). The current study found an ~5% reduction of the MVV due to the external load on the torso (i.e., PC+BA+LBE). That our mMOPP uniform configuration produced a smaller reduction in MVV than previously studied uniform and LBE combinations may be related to the total weight of the external load on the torso. In this study, the load (~11 kg) was smaller than those examined by the previous studies. Consequently, we expect that increasing the weight of the fighting load configuration will increase the elastic load on the chest wall, thus accentuating the breathing impairment. In addition to the total weight of the load on the torso, overgarments, BA and LBE that are too small for the soldier accentuate the "corset-like" restriction on the chest wall. In this study, the BA (BODY ARMOR, FRAGMENTATION, PROTECTIVE VEST, GROUND TROOP) was sized IAW the item's instructions over the BDU. Consequently, when worn over the MOPP overgarment, the fit was tight. Furthermore, we found that with over 50% of our soldier volunteers, the pistol belt could not be adequately lengthened to fit comfortably around the BA. Thus, BA and LBE appropriately sized for soldiers in MOPP 0 will likely be too small when wearing the MOPP I-IV uniforms and will impair breathing.

This study found that the mMOPP uniform configuration increased the stiffness of the chest wall. This presents an elastic load to breathing, which is usually compensated for by reducing the inspired volume of each breath and increasing the rate of breathing to maintain the desired minute ventilation (Agostoni et al., 1978). In addition to changing the pattern of breathing, restricting chest wall displacement requires increased respiratory muscle activity (Green et al., 1978). Our mMOPP uniform configuration included the M40 CB Mask with standard C2 filter. The CB mask presents two additional challenges to the ventilatory system: increased dead space and inspiratory resistance (Muza, 1986). The addition of dead space to the upper airway is typically compensated by increasing inspired volume. Likewise, when breathing against added inspiratory resistance, conscious humans usually increase inspired volume and inspiratory duration and decrease respiratory frequency (Muza et al., 1990). Thus, the ventilatory compensations

for increased dead space and inspiratory resistance are opposite to that used when ventilation is opposed by an elastic load (i.e., PC+BA+LBE). Prior to this study, the exercise ventilatory response to the combined effects of added air flow resistance, dead space and elastic loading as presented by the mMOPP uniform were unknown.

During our ~600 W submaximal exercise test, the pattern of exercise breathing was more influenced by the elastic forces opposing breathing rather than the resistive forces. The smaller tidal volume during exercise represents a compensation for the increased elastance of the respiratory system due to the wear of the MOPP overgarments, BA and LBE. With a smaller tidal volume, minute ventilation was maintained by increasing respiratory rate. Although we did not measure the human volunteers' respiratory system resistance, assuming a normal adult value we conclude that the CB Mask increases resistive opposition to breathing by ~75%, and the PC+BA+LBE increases the elastic opposition to breathing by ~16% over the mBDU configuration. What is surprising is though the PC+BA+LBE constituted a smaller impairment on the respiratory system than the CB mask, the subjects choose to adjust their pattern of breathing to compensate for this small elastic load rather than the larger resistive load opposing breathing. This suggests that elastic loads to breathing may not be subjectively tolerated as well as resistive loads (i.e., CB Mask). Thus, the constraint on the respiratory system imposed by external loading of the chest wall (clothing, BA, LBE) may present a significant mechanism for impairing exercise breathing and physical work performance.

In addition to the elastic load compensation, exercise ventilation in the mMOPP uniform configuration was a greater percentage of the subjects' maximal ventilatory capacity. A decreased BR indicates an increased strain on the respiratory system and increased incidence of adverse respiratory sensations (i.e., breathlessness, etc.). Although no subjects prematurely stopped the submaximal exercise test in either uniform configuration, these data indicate that in this mMOPP configuration the threshold for adverse and potentially performance-limiting respiratory sensations is reduced by ~50% compared to the mBDU uniform configuration.

An increase in the work of breathing or perception of adverse respiratory sensations may cause a soldier to hypoventilate. Although the group mean exercise ventilation was similar in both uniforms tests, nearly 25% of the subjects dropped their exercise minute ventilation by more than 10% in the mMOPP uniform compared to the mBDU. This suggests that within a population of normal healthy soldiers, a subset may be more susceptible to MOPP-induced respiratory impairment. However, even in this group of hypoventilators, the change (<3 mmHg) in the PAO_2 and $PACO_2$ was not of clinical significance.

We had hypothesized that the mMOPP uniform configuration tested would place a specific burden on the respiratory system. Analysis of the ventilatory data supports this idea. Whether or not this respiratory burden would extend to other organ systems was uncertain. Exercise heart rate was greater in the mMOPP compared to the mBDU uniforms. Given that the heat strain and metabolic rate were similar in both the mBDU and mMOPP uniform configurations, the elevated heart rate may have resulted from 1) reflexes arising from pulmonary or chest wall receptors, 2) musculoskeletal receptors responding to the increased torso loads, or 3) increased central command associated with perception of exertion. Subjects consistently rated their overall perception of effort (RPE) greater in the mMOPP than mBDU. Furthermore, in both uniforms, RPE increased with the duration of exercise. It has been proposed that perceptions of physical exertion are linked to signals involving sensations of strain in the working muscles (peripheral factors) and sensations of tachycardia, tachypnea and dyspnea (central factors). Of these cardiopulmonary responses, the relative contribution of ventilation to RPE is greater than HR or relative Vo_2 at moderate-to-high metabolic intensities (Robertson, 1982). Given that the metabolic intensity and thermal strain were similar in both uniform configurations tested, a greater RPE in the mMOPP may reflect the increased work of breathing brought about by the elastic and resistive loads imposed by the mMOPP uniform.

Another challenge to the ventilatory system is phonation (i.e., speech and singing). Phonation causes two major modifications to the breathing pattern: a larger proportion of the vital capacity is used and expiration is prolonged (Proctor, 1986). At rest, these disruptions of the breathing pattern do not cause hypoventilation. During MOPP studies

conducted by Institute personnel (Cadarette, 1992), personnel noted increased respiratory complaints immediately following rapid speech (i.e., performance testing requiring verbal responses to Serial Seven's Subtraction Task). Due to adequate ventilatory reserve capacity, speech does not appear to be a constraint on moderate intensity exercise performance, although this is not well studied (Proctor, 1986). However, as exercise intensity and thus ventilatory demand increase, most individuals find that attempting to maintain conversation adversely impairs physical performance. We hypothesize that if ventilatory capacity is already reduced by imposition of external mechanical constraints (NBC overgarments, CB mask, LBE), phonation-induced disruptions of the breathing pattern will precipitate a ventilatory limitation on moderate physical work performance. To our knowledge, no previous investigation has examined the effects of phonation concurrent with external respiratory loads on ventilation during exercise.

Volunteers performed the Serial Seven's Subtraction Task to measure cognitive performance and create reproducible, oral responses that disrupt the pattern of breathing during performance of this task. During the 3-minute speech task, minute ventilation was reduced compared to the steady-state exercise ventilation. The hypoventilation was most apparent during the first minute of the speech task, achieving ~11% reduction in minute ventilation. Furthermore, upon cessation of the speech task, minute ventilation tended to increase above steady-state levels, although this was not statistically significant. The effects of a speech task on exercise ventilation was identical in both uniform combinations. These data suggest that a sustained speaking task hinders the soldier's ability to maintain adequate exercise ventilation. Furthermore, although not evaluated, the speech task disrupts the breathing pattern rhythm which, combined with the hypoventilation, may promote development of adverse respiratory sensations and contribute to becoming a MOPP-induced casualty.

The Internal States Questionnaire (Table 11) and the Environmental Distress Questionnaire (Table 12) detected many effects of the type of uniform and the duration of exercise. It is interesting that our Internal States Questionnaire had more items that detected the adverse effects of mMOPP than did the Environmental Distress Questionnaire.

Measures of subjective heat illness were adversely affected by the duration of exercise; the type of uniform did not affect this well-published measure of heat illness. This suggests that our use of different environmental temperatures for testing each type of uniform and the modifications of the uniforms to increase heat loss were effective in producing equivalent perceptions of heat discomfort for each uniform type. This subjective measure is also consistent with the measure of internal body temperature in this study, which did not differ significantly for each uniform.

Moreover, four items on the Internal States Questionnaire (items 3, 13, 16, 17) yielded effects solely attributable to the type of uniform; the Environmental Distress Questionnaire possessed no items yielding such effects for the type of uniform. Such items concerned perceptions of anxiety, not getting enough air, not breathing the way one usually does, and not being relaxed. The fact that such effects are not related to the duration of exercise per se suggests that the uniform type itself creates changes in symptoms and perceived internal states that greatly influence the soldier's appraisal of discomfort and averseness in the situation.

In addition to the cognitive and subjective measures collected during the submaximal exercise, similar measures were performed during rest. The purpose of the Respiratory Challenge Test was to determine if information from this experimental manipulation, combined with military and background psychological information (Table 5), predict volunteers most likely to manifest adverse reactions to the CB mask. For this test, the volunteer wore the Army PT uniform and breathed for 30 minutes through the M40 CB mask with minimal inspiratory resistance (filter element removed from C-2 canister) and for 30 minutes with a supra-threshold inspiratory resistance (order of presentation was counterbalanced). This level of resistance approximated, during restful breathing, the airway pressure produced by moderate-intensity exercise hyperpnea through a standard C2 canister. This larger resistance was chosen in order to elicit measurable physiological and psychological load compensatory responses (Zechman and Wiley, 1986; Muza, 1986; Raven et al., 1979; Morgan, 1983). However, we found no measurable differences between these two resistance levels in the subject's ventilatory,

cognitive performance or subjective reactions. This suggests that the respiratory load presented was not of sufficient magnitude to elicit aversive responses under the conditions of this study. Given that ventilatory demand is low under restful conditions, a modification of this test incorporating either a higher resistance or increased ventilatory demand by carbon dioxide inhalation may warrant further study.

Use of our captured speech methodology in this study yielded subjective data that are likely to be more valid and more sensitive than other methodologies. Each subject listened to a behavioral specialist announce each statement from the Environmental Distress Questionnaire or Internal States Questionnaire. Then each subject said the statement number and his numerical rating for the statement. Observations during this and other experimental studies suggest that our captured speech methodology allows the subject to appraise his subjective status quickly. Furthermore, saying brief, low-intensity verbal responses (sensed by a microphone in the M40 CB mask) is less disruptive than indicating responses on a computer keyboard or completing a paper-and-pencil questionnaire when a soldier is physically active, performing other task activities, or encumbered by his duty uniform (e.g., MOPP IV). The sensitivity and validity of our captured speech measures, as well as their concordance with more objective measures of physical and biological states, suggest their utility in carefully designed and controlled studies of factors that limit work performance and comfort of the soldier.

This study demonstrated that in addition to the M40 CB mask, MOPP overgarments, BA, and LBE substantially restrict breathing. The last three items' constrictive liabilities to the chest wall can be minimized by wearing BA and LBE that are properly fitted over the protective clothing. Future designs of these uniforms and personal equipment for the soldier may incorporate enhancements that allow for outward expansion of the uniform, BA, or LBE with inhalation. Finally, since our data suggest that the elastic forces opposing breathing produce greater adjustments of the breathing pattern than the resistive forces contributed by the M40 CB mask, incorporation of elastic loading in training programs to improve work performance and tolerance in MOPP may prove beneficial in reducing ventilatory casualties in the MOPP.

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APPENDIX 1: CHARACTERISTICS OF TEST VOLUNTEERS

Fig. A01 Ages of military test volunteers.

The ages of the military volunteers in this P2NBC2 study were similar to that of volunteers in two other recent P2NBC2 studies by Blewett et. al (1992, 1993). The median ages of our military volunteers and those in Blewett et. al (1992) were 22 to 23 years; however, there were fewer younger soldiers (18 to 21-years-old) in our study. In the more recent field study of Blewett et. al (1993) the median age of the military volunteers was 24-years-old. These data suggest that the ages of the military volunteers were similar in these three P2NBC2 studies (one laboratory study and two field studies).

APPENDIX 1: CHARACTERISTICS OF TEST VOLUNTEERS

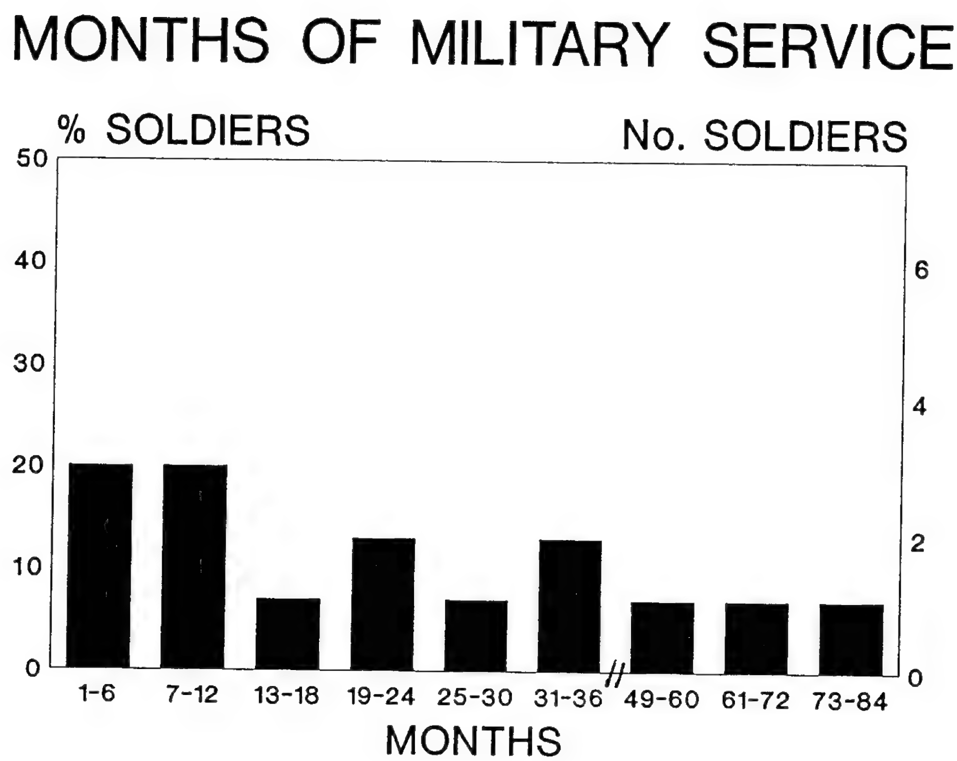

Fig. A02 Months of military service of the test volunteers.

In a field study of Blewett et. al (1992) and this laboratory study, soldiers served in the military service for similar durations (18 versus 20 months). The soldiers in our study had much less time in the service (median of 21 versus 36 months) than the volunteers in another study by Blewett et. al (1993). Another indication that these soldiers serviced longer was that over 25% of these soldiers had 72 to 120 months of time in service.

APPENDIX 1: CHARACTERISTICS OF TEST VOLUNTEERS

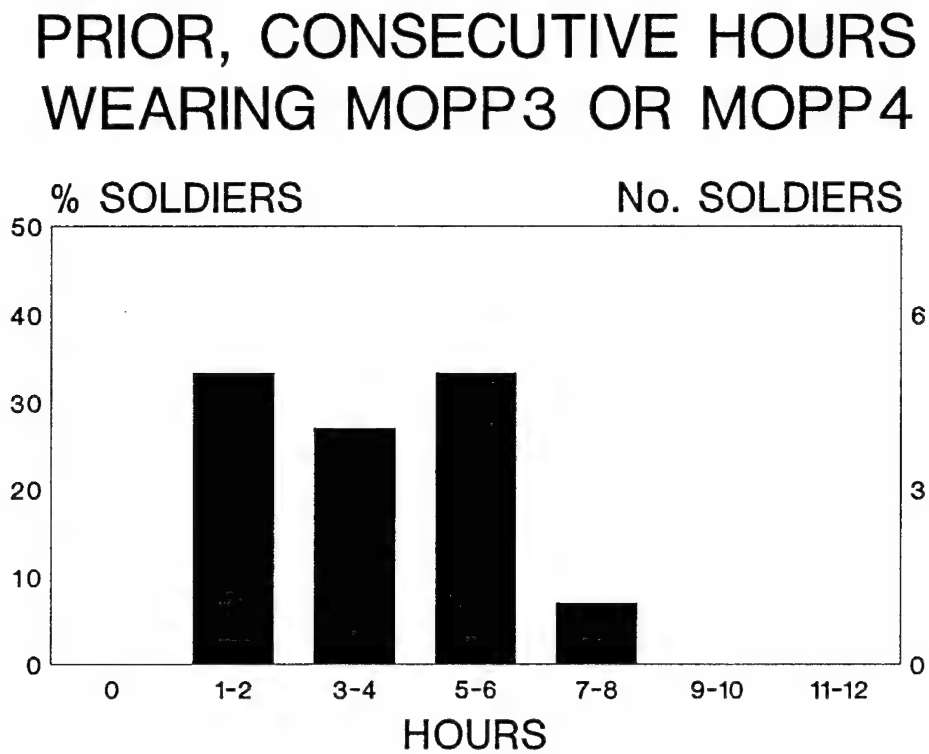

Fig. A03 Maximum, number of consecutive hours that the test volunteers wore the chemical protective ensemble (MOPP3 or MOPP4 level) before this study.

Prior to this study, our soldiers wore the chemical protective ensemble fewer consecutive hours than the soldiers in both field studies of Blewett et. al (1992, 1993) had previously. The median value for soldiers in this study was 3 to 4 hours compared to 5 to 6 hours for volunteer soldiers in the studies of Blewett et. al (1992, 1993). Soldiers assigned to units which trained more with the chemical defense ensemble or with greater time in service probably contributed to these differences.

APPENDIX 2: MILITARY AND PERSONAL HISTORY SURVEY

MILITARY & PERSONAL HISTORY SURVEY

AGE:__ __
0 1 2 3 4 5 6 7 8 9

SUBJECT NUMBER: __ __
0 1 2 3 4 5 6 7 8 9

SEX:
- [ ] Male
- [ ] Female

MILITARY HISTORY

1. What year did you come on active duty?
   year __ __
   0 1 2 3 4 5 6 7 8 9

2. What year is your ETS?
   year __ __
   0 1 2 3 4 5 6 7 8 9

3. What year is your date of rank?
   year __ __
   0 1 2 3 4 5 6 7 8 9

4. Do you plan on making the Army a career?
   - [ ] Yes
   - [ ] No
   - [ ] Undecided

5. What is your Primary MOS?__________

6. What is your Secondary MOS?__________

7. What is your duty MOS?__________

8. If you answered NO or UNDECIDED to question #4, what are your reasons for getting out? (Mark all that apply)
   - [ ] Better pay outside
   - [ ] Medical reasons
   - [ ] Returning to school
   - [ ] Family reasons
   - [ ] Dislike the military
   - [ ] Dislike officers and/or NCOs
   - [ ] Too long at one assignment
   - [ ] Don't believe in what I'm doing
   - [ ] Personal problems
   - [ ] Conflicts with "spouse's" career
   - [ ] Have been selected for QMP/ being Chaptered out
   - [ ] Too little freedom
   - [ ] Better job elsewhere
   - [ ] Hours too long
   - [ ] Work too hard
   - [ ] "Just plain fed up!"
   - [ ] Other reasons
   - [ ] "Spouse" dislikes military service
   - [ ] Military is too regimented

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9. What year were you born?
   year__ __
   0 1 2 3 4 5 6 7 8 9

10. What is your Main ethnic background? (from your natural parents)
    - [ ] Black
    - [ ] Hispanic
    - [ ] Non-Hispanic White
    - [ ] Aisan/Pacific Islander
    - [ ] Native American
    - [ ] Don't Know
    - [ ] Other__________

11. How motivated are you to perform well and complete this experiment?
    POORLY [ ] [ ] AVERAGE [ ] [ ] EXTREMELY WELL [ ]

12. What is the highest level of education you have attained?
    - [ ] Less than G.E.D.
    - [ ] G.E.D
    - [ ] High School Graduate
    - [ ] 1 Year College
    - [ ] 2-3 Years college
    - [ ] College Graduate
    - [ ] Master's
    - [ ] Ph.D., M.D., etc.

13. Do you chew tobacco?
    - [ ] Yes
    - [ ] No

14. Do you use snuff?
    - [ ] Yes
    - [ ] No

15. Do you smoke?
    - [ ] Yes
    - [ ] No

16. OMIT

17. Which heat injuries have you experienced? (Check all that apply)
    - [ ] Heat cramps
    - [ ] Heat exhaustion
    - [ ] Heat stroke
    - [ ] No heat injuries

18. How many total times have you worn MOPP 3 or MOPP 4.
    __ __
    0 1 2 3 4 5 6 7 8 9

19. What is the maximum number of hours you have worn MOPP 3 or MOPP 4 continuously?
    __ __
    0 1 2 3 4 5 6 7 8 9

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SURVEY NETWORK

APPENDIX 2: MILITARY AND PERSONAL HISTORY SURVEY

20. How many chemical defense exercises have you participated in? __ __

0 1 2 3 4 5 6 7 8 9

21. How many chemical defense exercises have you participated in during the past year? __ __

0 1 2 3 4 5 6 7 8 9

22. What was your last PT score? __ __ __

0 1 2 3 4 5 6 7 8 9

23. What were your raw scores on your last PT test?

2 mile run: min __ __ secs __ __

sit-ups __ __ __

pushups __ __ __

0 1 2 3 4 5 6 7 8 9

24. How tall are you?______

FEET __

0 1 2 3 4 5 6 7

INCHES __ __

0 1 2 3 4 5 6 7 8 9

25. What is your weight in pounds?________ __ __ __

0 1 2 3 4 5 6 7 8 9

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Consider this definition of Sustained Operations in answering questions 26 and 27.

Sustained Operations - - - Intensive mission demands lasting 48 hours or more which allows less than four (4) hours sleep per night.

26. How many times have you participated in sustained operations? __ __

0 1 2 3 4 5 6 7 8 9

27. How many consecutive days of sustained operations have you participated in at any one time? __ __

0 1 2 3 4 5 6 7 8 9

28. Where would you usually do your job during combat?

- [ ] Inside of vehicle or shelter
- [ ] Outside of vehicle or shelter

29. What is your rank (Grade)?

- [ ] E-1
- [ ] E-2
- [ ] E-3
- [ ] E-4
- [ ] E-5
- [ ] E-6
- [ ] E-7
- [ ] E-8
- [ ] E-9
- [ ] O-1
- [ ] O-2
- [ ] O-3
- [ ] O-4
- [ ] O-5
- [ ] O-6

30. What is your job title?________________

31. Length of time on Active Duty?________

YEARS __ __

0 1 2 3 4 5 6 7 8 9

MONTHS __ __

0 1 2 3 4 5 6 7 8 9

32. Number of months you have been stationed with this unit (company, battery, etc)? __ __ __

0 1 2 3 4 5 6 7 8 9

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33. Were you deployed to the Persian Gulf for "Operation Desert Shield/Storm"?

- ☐ Yes
- ☐ No

NOTE: If you answer yes to #33 answer the questions 33a-33d below, otherwise skip to question #34.

33a. How many months were you stationed in the Persian Gulf? ___ months

0 1 2 3 4 5 6 7 8 9

33b. Did you take the pre-treatment medication PB tablets? (to protect against attack with chemical agents)

- ☐ Yes
- ☐ No

33c. Did you experience any pleasant effects from taking this medication?

- ☐ Yes, Specifically, I experienced____________________
- ☐ No

33d. Did you experience any unpleasant or adverse effects from taking this medication?

- ☐ Yes, Specifically, I experienced____________________
- ☐ No

34. Do you wear contact lenses or prescription lenses?

- ☐ Yes Which type?____________________
- ☐ No

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SURVEY NETWORK

NOTE: If you answer yes to #34 answer the questions 34a-34b below, otherwise skip to question #35.

34a. Which type of visual problem do they correct?

- ☐ Nearsightedness (myopia)
- ☐ Farsightedness
- ☐ Astigmatism

34b. Do you have prescription lens inserts for your chemical protective mask?

- ☐ Yes
- ☐ No

35. Were either your mother or father in the military service for 10 years or more?

- ☐ Yes
- ☐ No

36. Today, what is your "relationship" status?

- ☐ single
- ☐ dating, involved
- ☐ "living with someone"
- ☐ married
- ☐ separated
- ☐ divorced
- ☐ widowed

37. Check any event below that you have experienced within the past 12 months. (Check all that apply)

- ☐ death of your "special person" or an immediate family member
- ☐ received a special award or citation
- ☐ experienced child custody issues
- ☐ took a vacation
- ☐ loss of your "special person's" or spouse's job
- ☐ marked involvement with the courts and legal system
- ☐ significant medical procedures to your "special person" or an immediate family member
- ☐ divorce
- ☐ moved to another residence
- ☐ critical sickness of your "special person" or an immediate family member

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SURVEY NETWORK

APPENDIX 2: SCL-90-R QUESTIONNAIRE

SCL-90-R®

Leonard R. Derogatis, Ph.D.

FOR USE WITH
MICROTEST™ Assessment System
and
Arion II® Teleprocessing Service

IDENTIFICATION NUMBER	AGE	SEX	TESTING DATE	DAY	YEAR
0 0	0 0	1 MALE	1 JAN		
1 1	1 1	2 FEMALE	2 FEB		
2 2	2 2		3 MAR	0 0	0
3 3	3 3		4 APR	1 1	1
4 4	4 4		5 MAY	2 2	2
5 5	5 5		6 JUN	3 3	3
6 6	6 6		7 JUL	4	4
7 7	7 7		8 AUG	5	5
8 8	8 8		9 SEP	6	6
9 9	9 9		10 OCT	7	7
			11 NOV	8 8	8
			12 DEC	9 9	9

DIRECTIONS:

Please follow these directions when completing the identification areas on this page and responding to the SCL-90-R test items.

1. Print your identification number in the boxes. Then blacken the circle below each box which corresponds to the number in the box. In a similar manner, complete the other grids.
2. Use a soft, black lead pencil only and make a heavy, dark mark when filling in the circles.
3. If you make a mistake or change your mind, please erase the mark fully and then fill in the correct circle.
4. Please do not make any marks outside the circles.

NATIONAL COMPUTER SYSTEMS
PROFESSIONAL ASSESSMENT SERVICES

INSTRUCTIONS:

Below is a list of problems people sometimes have. Please read each one carefully, and blacken the circle that best describes HOW MUCH THAT PROBLEM HAS DISTRESSED OR BOTHERED YOU DURING THE PAST 7 DAYS INCLUDING TODAY. Blacken the circle for only one number for each problem and do not skip any items. If you change your mind, erase your first mark carefully. Read the example before beginning, and if you have any questions please ask about them.

EXAMPLE

NOT AT ALL	A LITTLE BIT	MODERATELY	QUITE A BIT	EXTREMELY	HOW MUCH WERE YOU DISTRESSED BY:
0	1	2	●	4	1. Bodyaches

14547

PLEASE DO NOT WRITE IN THIS SHADED AREA

NOT AT ALL	A LITTLE BIT	MODERATELY	QUITE A BIT	EXTREMELY	HOW MUCH WERE YOU DISTRESSED BY:
0	1	2	3	4	1. Headaches
0	1	2	3	4	2. Nervousness or shakiness inside
0	1	2	3	4	3. Repeated unpleasant thoughts that won't leave your mind
0	1	2	3	4	4. Faintness or dizziness
0	1	2	3	4	5. Loss of sexual interest or pleasure
0	1	2	3	4	6. Feeling critical of others
0	1	2	3	4	7. The idea that someone else can control your thoughts
0	1	2	3	4	8. Feeling others are to blame for most of your troubles
0	1	2	3	4	9. Trouble remembering things
0	1	2	3	4	10. Worried about sloppiness or carelessness
0	1	2	3	4	11. Feeling easily annoyed or irritated
0	1	2	3	4	12. Pains in heart or chest
0	1	2	3	4	13. Feeling afraid in open spaces or on the streets
0	1	2	3	4	14. Feeling low in energy or slowed down
0	1	2	3	4	15. Thoughts of ending your life
0	1	2	3	4	16. Hearing voices that other people do not hear
0	1	2	3	4	17. Trembling
0	1	2	3	4	18. Feeling that most people cannot be trusted
0	1	2	3	4	19. Poor appetite
0	1	2	3	4	20. Crying easily
0	1	2	3	4	21. Feeling shy or uneasy with the opposite sex
0	1	2	3	4	22. Feelings of being trapped or caught
0	1	2	3	4	23. Suddenly scared for no reason
0	1	2	3	4	24. Temper outbursts that you could not control
0	1	2	3	4	25. Feeling afraid to go out of your house alone
0	1	2	3	4	26. Blaming yourself for things
0	1	2	3	4	27. Pains in lower back
0	1	2	3	4	28. Feeling blocked in getting things done
0	1	2	3	4	29. Feeling lonely
0	1	2	3	4	30. Feeling blue

Please continue on the following page

NOT AT ALL	A LITTLE BIT	MODERATELY	QUITE A BIT	EXTREMELY	HOW MUCH WERE YOU DISTRESSED BY:
0	1	2	3	4	31. Worrying too much about things
0	1	2	3	4	32. Feeling no interest in things
0	1	2	3	4	33. Feeling fearful
0	1	2	3	4	34. Your feelings being easily hurt
0	1	2	3	4	35. Other people being aware of your private thoughts
0	1	2	3	4	36. Feeling others do not understand you or are unsympathetic
0	1	2	3	4	37. Feeling that people are unfriendly or dislike you
0	1	2	3	4	38. Having to do things very slowly to insure correctness
0	1	2	3	4	39. Heart pounding or racing
0	1	2	3	4	40. Nausea or upset stomach
0	1	2	3	4	41. Feeling inferior to others
0	1	2	3	4	42. Soreness of your muscles
0	1	2	3	4	43. Feeling that you are watched or talked about by others
0	1	2	3	4	44. Trouble falling asleep
0	1	2	3	4	45. Having to check and double-check what you do
0	1	2	3	4	46. Difficulty making decisions
0	1	2	3	4	47. Feeling afraid to travel on buses, subways, or trains
0	1	2	3	4	48. Trouble getting your breath
0	1	2	3	4	49. Hot or cold spells
0	1	2	3	4	50. Having to avoid certain things, places, or activities because they frighten you
0	1	2	3	4	51. Your mind going blank
0	1	2	3	4	52. Numbness or tingling in parts of your body
0	1	2	3	4	53. A lump in your throat
0	1	2	3	4	54. Feeling hopeless about the future
0	1	2	3	4	55. Trouble concentrating
0	1	2	3	4	56. Feeling weak in parts of your body
0	1	2	3	4	57. Feeling tense or keyed up
0	1	2	3	4	58. Heavy feelings in your arms or legs
0	1	2	3	4	59. Thoughts of death or dying
0	1	2	3	4	60. Overeating
0	1	2	3	4	61. Feeling uneasy when people are watching or talking about you
0	1	2	3	4	62. Having thoughts that are not your own
0	1	2	3	4	63. Having urges to beat, injure, or harm someone
0	1	2	3	4	64. Awakening in the early morning
0	1	2	3	4	65. Having to repeat the same actions such as touching, counting, or washing
0	1	2	3	4	66. Sleep that is restless or disturbed
0	1	2	3	4	67. Having urges to break or smash things
0	1	2	3	4	68. Having ideas or beliefs that others do not share
0	1	2	3	4	69. Feeling very self-conscious with others
0	1	2	3	4	70. Feeling uneasy in crowds, such as shopping or at a movie
0	1	2	3	4	71. Feeling everything is an effort
0	1	2	3	4	72. Spells of terror or panic
0	1	2	3	4	73. Feeling uncomfortable about eating or drinking in public
0	1	2	3	4	74. Getting into frequent arguments
0	1	2	3	4	75. Feeling nervous when you are left alone
0	1	2	3	4	76. Others not giving you proper credit for your achievements
0	1	2	3	4	77. Feeling lonely even when you are with people
0	1	2	3	4	78. Feeling so restless you couldn't sit still
0	1	2	3	4	79. Feelings of worthlessness
0	1	2	3	4	80. The feeling that something bad is going to happen to you
0	1	2	3	4	81. Shouting or throwing things
0	1	2	3	4	82. Feeling afraid you will faint in public
0	1	2	3	4	83. Feeling that people will take advantage of you if you let them
0	1	2	3	4	84. Having thoughts about sex that bother you a lot
0	1	2	3	4	85. The idea that you should be punished for your sins
0	1	2	3	4	86. Thoughts and images of a frightening nature
0	1	2	3	4	87. The idea that something serious is wrong with your body
0	1	2	3	4	88. Never feeling close to another person
0	1	2	3	4	89. Feelings of guilt
0	1	2	3	4	90. The idea that something is wrong with your mind

APPENDIX 2: BDI AND BHS QUESTIONNAIRES

BDI and BHS

Aaron T. Beck

FOR USE WITH
MICROTEST™ Assessment System

IDENTIFICATION NUMBER | AGE | SEX: (1) MALE (2) FEMALE | TESTING DATE: DAY, YEAR; (1) JAN (2) FEB (3) MAR (4) APR (5) MAY (6) JUN (7) JUL (8) AUG (9) SEP (10) OCT (11) NOV (12) DEC

TEST (S) ADMINISTERED
(1) BDI AND BHS (2) BDI ONLY

DIRECTIONS:

Please follow these directions when completing the identification areas on this page and responding to the BDI and BHS test items.

1. **Print your identification number in the boxes. Then blacken the circle below each box which corresponds to the number in the box. In a similar manner, complete the other grids.**
2. **Use a soft, black lead pencil only and make a heavy, dark mark when filling in the circles.**
3. **If you make a mistake or change your mind, please erase the mark fully and then fill in the correct circle.**
4. **Please do not make any marks outside the circles.**

NATIONAL COMPUTER SYSTEMS
PROFESSIONAL ASSESSMENT SERVICES

BDI

This questionnaire consists of 22 groups of statements. After reading each group of statements carefully, select the number (0, 1, 2, or 3) next to the one statement in each group which best describes the way you have been feeling the past week, including today. Be sure to read all the statements in each group before making your choice.

1. (0) I do not feel sad.
(1) I feel sad.
(2) I am sad all the time and I can't snap out of it.
(3) I am so sad or unhappy that I can't stand it.

2. (0) I am not particularly discouraged about the future.
(1) I feel discouraged about the future.
(2) I feel I have nothing to look forward to.
(3) I feel that the future is hopeless and that things cannot improve.

3. (0) I do not feel like a failure.
(1) I feel I have failed more than the average person.
(2) As I look back on my life, all I can see is a lot of failures.
(3) I feel I am a complete failure as a person.

4. (0) I get as much satisfaction out of things as I used to.
(1) I don't enjoy things the way I used to.
(2) I don't get real satisfaction out of anything anymore.
(3) I am dissatisfied or bored with everything.

5. (0) I don't feel particularly guilty.
(1) I feel guilty a good part of the time.
(2) I feel quite guilty most of the time.
(3) I feel guilty all of the time.

6. (0) I don't feel I am being punished.
(1) I feel I may be punished.
(2) I expect to be punished.
(3) I feel I am being punished.

12643
PLEASE DO NOT WRITE IN THIS AREA

50032

7. (0) I don't feel disappointed in myself.
(1) I am disappointed in myself.
(2) I am disgusted with myself.
(3) I hate myself.

8. (0) I don't feel I am any worse than anybody else.
(1) I am critical of myself for my weaknesses or mistakes.
(2) I blame myself all the time for my faults.
(3) I blame myself for everything bad that happens.

9. (0) I don't have any thoughts of killing myself.
(1) I have thoughts of killing myself, but I would not carry them out.
(2) I would like to kill myself.
(3) I would kill myself if I had the chance.

10. (0) I don't cry any more than usual.
(1) I cry more now than I used to.
(2) I cry all the time now.
(3) I used to be able to cry, but now I can't cry even though I want to.

11. (0) I am no more irritated now than I ever am.
(1) I get annoyed or irritated more easily than I used to.
(2) I feel irritated all the time now.
(3) I don't get irritated at all by the things that used to irritate me.

12. (0) I have not lost interest in other people.
(1) I am less interested in other people than I used to be.
(2) I have lost most of my interest in other people.
(3) I have lost all of my interest in other people.

13. (0) I make decisions about as well as I ever could.
(1) I put off making decisions more than I used to.
(2) I have greater difficulty in making decisions than before.
(3) I can't make decisions at all anymore.

14. (0) I don't feel I look any worse than I used to.
(1) I am worried that I am looking old or unattractive.
(2) I feel that there are permanent changes in my appearance that make me look unattractive.
(3) I believe that I look ugly.

15. (0) I can work about as well as before.
(1) It takes an extra effort to get started at doing something.
(2) I have to push myself very hard to do anything.
(3) I can't do any work at all.

16. (0) I can sleep as well as usual.
(1) I don't sleep as well as I used to.
(2) I wake up 1-2 hours earlier than usual and find it hard to get back to sleep.
(3) I wake up several hours earlier than I used to and cannot get back to sleep.

17. (0) I don't get more tired than usual.
(1) I get tired more easily than I used to.
(2) I get tired from doing almost anything.
(3) I am too tired to do anything.

18. (0) My appetite is no worse than usual.
(1) My appetite is not as good as it used to be.
(2) My appetite is much worse now.
(3) I have no appetite at all anymore.

19. (0) I haven't lost much weight, if any, lately.
(1) I have lost more than 5 pounds.
(2) I have lost more than 10 pounds.
(3) I have lost more than 15 pounds.

20. I am purposely trying to lose weight by eating less.
(1) Yes
(2) No

21. (0) I am no more worried about my health than usual.
(1) I am worried about physical problems such as aches and pains; or upset stomach; or constipation.
(2) I am very worried about physical problems and it's hard to think of much else.
(3) I am so worried about my physical problems that I cannot think about anything else.

22. (0) I have not noticed any recent change in my interest in sex.
(1) I am less interested in sex than I used to be.
(2) I am much less interested in sex now.
(3) I have lost interest in sex completely.

APPENDIX 2: BDI AND BHS QUESTIONNAIRES

BHS

This questionnaire consists of 20 statements. Please read the statements carefully one by one. If the statement describes your attitude for the past week including today, darken the circle marked Ⓣ indicating TRUE in the column next to the statement. If the statement does not describe your attitude, darken the circle marked Ⓕ indicating FALSE in the column next to this statement. Please be sure to read each statement carefully.

1. Ⓣ Ⓕ I look forward to the future with hope and enthusiasm.
2. Ⓣ Ⓕ I might as well give up because there is nothing I can do about making things better for myself.
3. Ⓣ Ⓕ When things are going badly, I am helped by knowing that they cannot stay that way forever.
4. Ⓣ Ⓕ I can't imagine what my life would be like in ten years.
5. Ⓣ Ⓕ I have enough time to accomplish the things I want to do.
6. Ⓣ Ⓕ In the future, I expect to succeed in what concerns me most.
7. Ⓣ Ⓕ My future seems dark to me.
8. Ⓣ Ⓕ I happen to be particularly lucky, and I expect to get more of the good things in life than the average person.
9. Ⓣ Ⓕ I just can't get the breaks, and there's no reason I will in the future.
10. Ⓣ Ⓕ My past experiences have prepared me well for the future.
11. Ⓣ Ⓕ All I can see ahead of me is unpleasantness rather than pleasantness.
12. Ⓣ Ⓕ I don't expect to get what I really want.
13. Ⓣ Ⓕ When I look ahead to the future, I expect that I will be happier than I am now.
14. Ⓣ Ⓕ Things just don't work out the way I want them to.
15. Ⓣ Ⓕ I have great faith in the future.
16. Ⓣ Ⓕ I never get what I want, so it's foolish to want anything.
17. Ⓣ Ⓕ It's very unlikely that I will get any real satisfaction in the future.
18. Ⓣ Ⓕ The future seems vague and uncertain to me.
19. Ⓣ Ⓕ I can look forward to more good times than bad times.
20. Ⓣ Ⓕ There's no use in really trying to get anything I want because I probably won't get it.

APPENDIX 2: SELF-EVALUATION QUESTIONNAIRE

SELF-EVALUATION QUESTIONNAIRE

STAI FORM X-2

NAME ______________________ DATE __________

DIRECTIONS: A number of statements which people have used to describe themselves are given below. Read each statement and then blacken in the appropriate circle to the right of the statement to indicate how you *generally* feel. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe how you generally feel.

	ALMOST NEVER	SOMETIMES	OFTEN	ALMOST ALWAYS
21. I feel pleasant	①	②	③	④
22. I tire quickly	①	②	③	④
23. I feel like crying	①	②	③	④
24. I wish I could be as happy as others seem to be	①	②	③	④
25. I am losing out on things because I can't make up my mind soon enough	①	②	③	④
26. I feel rested	①	②	③	④
27. I am "calm, cool, and collected"	①	②	③	④
28. I feel that difficulties are piling up so that I cannot overcome them	①	②	③	④
29. I worry too much over something that really doesn't matter	①	②	③	④
30. I am happy	①	②	③	④
31. I am inclined to take things hard	①	②	③	④
32. I lack self-confidence	①	②	③	④
33. I feel secure	①	②	③	④
34. I try to avoid facing a crisis or difficulty	①	②	③	④
35. I feel blue	①	②	③	④
36. I am content	①	②	③	④
37. Some unimportant thought runs through my mind and bothers me	①	②	③	④
38. I take disappointments so keenly that I can't put them out of my mind	①	②	③	④
39. I am a steady person	①	②	③	④
40. I get in a state of tension or turmoil as I think over my recent concerns and interests	①	②	③	④

APPENDIX 2

ENVIRONMENTAL DISTRESS QUESTIONNAIRE

Date:__________ Subject ID:____________ trial: BDU MOPP 1 2

0 = Not At All 1 = Slight 2 = Somewhat 3 = Moderate 4 = Quite A Bit 5 = Extreme

INSTRUCTIONS: Rate each statement how you feel NOW--at this moment.

1. I feel lightheaded.____
2. I have a headache.____
3. I feel dizzy.____
4. I feel faint.____
5. My coordination is off.____
6. I'm short of breath.____
7. It's hard to breathe.____
8. It hurts to breathe.____
9. My heart is beating fast.____
10. I have muscle cramps.____
11. I have stomach cramps.____
12. I feel weak.____
13. I feel sick to my stomach (nauseous).____
14. I'm constipated.____
15. I feel warm.____
16. I'm sweating all over.____
17. Parts of my body feel numb.____
18. My vision is blurry.____
19. I've lost my appetite.____
20. I feel sick.____
21. I'm thirsty.____
22. I feel tired.____
23. I feel irritable.____
24. I feel restless.____

APPENDIX 2

INTERNAL STATES QUESTIONNAIRE

Date:__________ Subject ID:_______________ trial: BDU MOPP 1 2

0 = Not At All 1 = Slight 2 = Somewhat 3 = Moderate 4 = Quite A Bit 5 = Extreme

INSTRUCTIONS: Rate each statement how you feel NOW--at this moment.

1. I feel "claustrophobic."_____
2. I can easily exhale the air from my lungs._____
3. I feel anxious._____
4. My lungs hurt._____
5. I think I can "get thru" these conditions for an additional 30 minutes or more.____
6. I feel "great."____
7. I feel I can not continue much longer.____
8. I feel as good as I usually feel.____
9. I feel tense.____
10. My chest feels like it does when I have a cold or infection._____
11. My mental activities and bodily movements are well coordinated.____
12. My vision is not as good as usual.____
13. When I breathe, I feel like I can not get enough air.____
14. I like this experience.____
15. It feels like I have "butterflies in my stomach."____
16. I am breathing the way I usually do.____
17. I am relaxed.____
18. This condition requires extra effort to breathe.____
19. I feel "tingling" on some parts of my body.____
20. I am coping well with these conditions.____
21. I am "in touch" with the different parts of my body.____
22. It is hard to get my body to do what I want._____
23. This situation seems easy enough to endure._____
24. My memory and attention are functioning as well as usual._____
25. It feels like I can not breathe fast enough._____
26. I like these conditions._____
27. I feel like I'm suffocating._____
28. I am uncomfortable._____

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